

CS6923 Final project

Part A - KNN, IRT, Neural Networks

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1. k-Nearest Neighbor

(a)

====Answer (a)====

Validation Accuracy: 0.6244707874682472

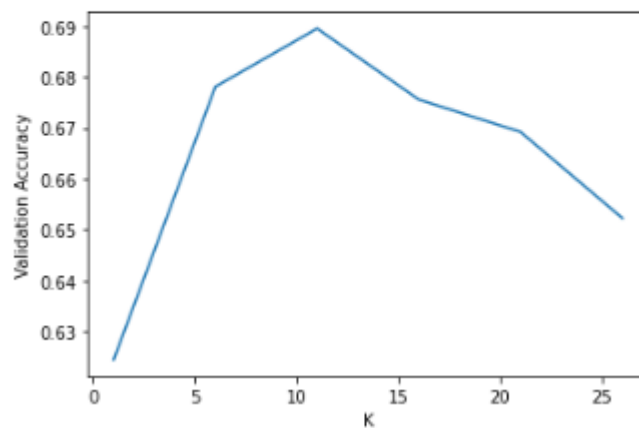
Validation Accuracy: 0.6780976573525261

Validation Accuracy: 0.6895286480383855

Validation Accuracy: 0.6755574372001129

Validation Accuracy: 0.6692068868190799

Validation Accuracy: 0.6522720858029918



(b)

====Answer (b)====

k that has the highest performance on validation data: 11

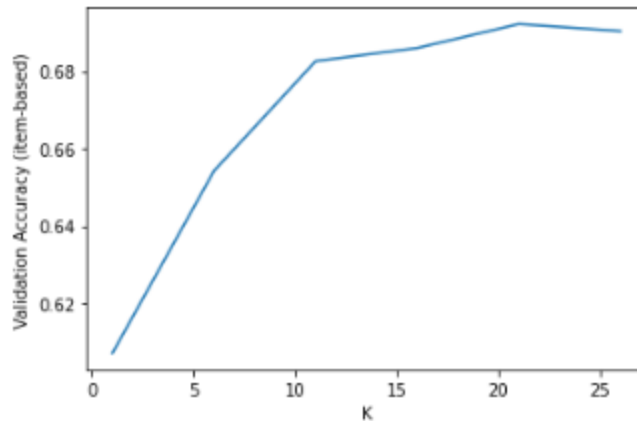
Validation Accuracy: 0.6841659610499576

The final test accuracy: 0.6841659610499576

(c)

====Answer (c)====

Validation Accuracy: 0.607112616426757
Validation Accuracy: 0.6542478125882021
Validation Accuracy: 0.6826136042901496
Validation Accuracy: 0.6860005644933672
Validation Accuracy: 0.6922099915325995
Validation Accuracy: 0.69037538808919



k that has the highest performance on validation data (item-based): 21
Validation Accuracy: 0.6689246401354784
The final test accuracy (item-based): 0.6689246401354784

(c) State the underlying assumption on itembased collaborative filtering:

- The underlying assumption of item based collaborative filtering is that if a person X has the same output (e.g., opinion) as a person Y on a task or issue, X is more likely to have Y's opinion on other different tasks/issues than those of a randomly chosen person.
- This approach is useful when we have many items (e.g., questions) with fewer those are related.

(d)

====Answer (d)====

user-based filtering performs better than item-based for 0.015241320914479273.

(e)

(e) List at least two potential limitations of kNN for the task you are given.

- kNN could perform slowly and be computationally intensive, especially when our datasets are large, assuming that online materials will easily be a huge amount of data collected.
- It is sometimes difficult to grasp the reason why the model is making certain predictions as kNN is not a parametric model though kNN could capture complex patterns of data that are challenging to model with other parametric methods.
- Picking not the best k will easily cause poor predictions; when k is too small, the underlying patterns in the data might not be able to be captured by the model, and if k is too large, the model may have a chance to be overly influenced by outliers or noise in the data.

2. Item Response Theory

(a)

$$p(c_{ij}=1 | \theta_i, B_j) = \frac{\exp(\theta_i - B_j)}{1 + \exp(\theta_i - B_j)}$$

$$p(c_{ij}=0 | \theta_i, B_j) = 1 - p(c_{ij}=1 | \theta_i, B_j)$$

$$= \frac{1 + \exp(\theta_i - B_j) - \exp(\theta_i - B_j)}{1 + \exp(\theta_i - B_j)}$$

$$= \frac{1}{1 + \exp(\theta_i - B_j)}$$

$$p(c_{ij} | \theta_i, B_j) = \frac{(\exp(\theta_i - B_j))^{c_{ij}}}{1 + \exp(\theta_i - B_j)}$$

$$p(C | \vec{\theta}, \vec{B}) = \prod_{i=1}^n \prod_{j=1}^m p(c_{ij} | \theta_i, B_j)$$

Let n = the number of students (542)

Let m = the number of questions (1774)

$$\log p(C | \vec{\theta}, \vec{B}) = \sum_{i=1}^n \sum_{j=1}^m \log p(c_{ij} | \theta_i, B_j)$$

$$= \sum_{i=1}^n \sum_{j=1}^m \log \left(\frac{(\exp(\theta_i - B_j))^{c_{ij}}}{1 + \exp(\theta_i - B_j)} \right)$$

$$= \sum_{i=1}^n \sum_{j=1}^m (c_{ij} \log(\exp(\theta_i - B_j)) - \log(1 + \exp(\theta_i - B_j)))$$

$$= \sum_{i=1}^n \sum_{j=1}^m ((c_{ij})(\theta_i - B_j) - \log(1 + \exp(\theta_i - B_j)))$$

Let us label the log-likelihood L

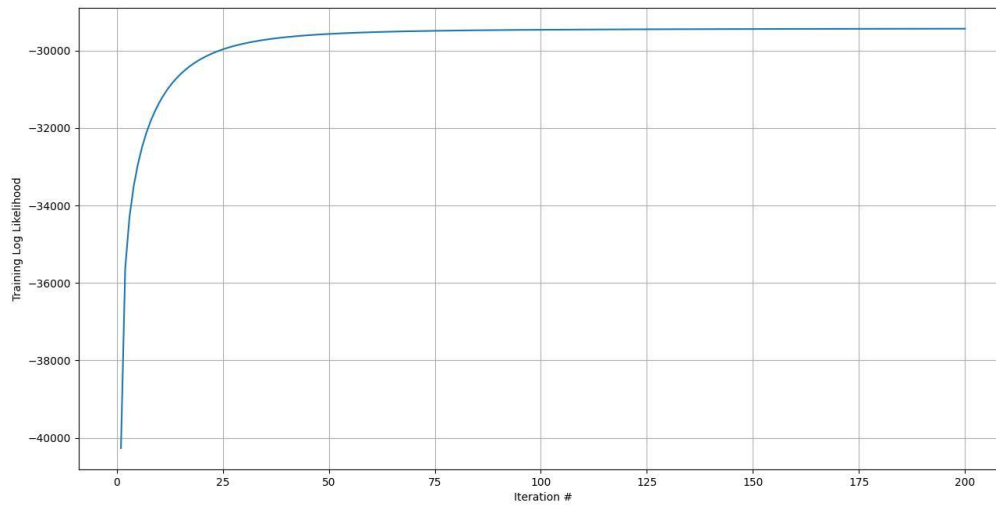
$$\frac{\partial L}{\partial \theta_i} = \sum_{j=1}^m \left(c_{ij} - \frac{\exp(\theta_i - B_j)}{1 + \exp(\theta_i - B_j)} \right)$$

$$\frac{\partial L}{\partial B_j} = \sum_{i=1}^n \left(\frac{\exp(\theta_i - B_j)}{1 + \exp(\theta_i - B_j)} - c_{ij} \right)$$

- b)

Tuned Hyperparameters that were used for the model:

- Number of iterations : 200
- Learning rate: 0.01

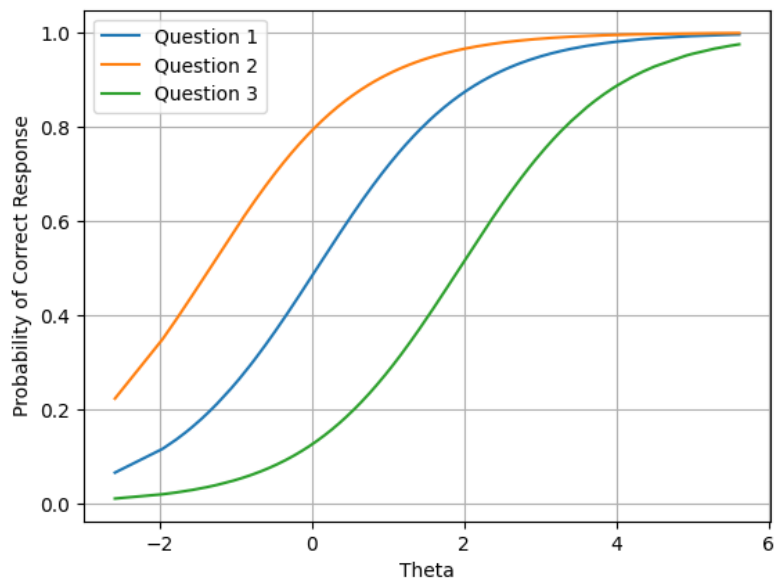


c)

Final Validation Accuracy: 0.70674569573807

Final Test Accuracy: 0.7084391758396

d)



3. Neural Networks

(b)

k^* that has the highest validation accuracy: 500

✂ *Training result of the autoencoder using $k \in \{10, 50, 100, 200, 500\}$:*

```
k = 10
Epoch: 0   Training Cost: 13335.003088   Valid Acc: 0.6278577476714648
Epoch: 1   Training Cost: 12558.676209   Valid Acc: 0.62884561106407
Epoch: 2   Training Cost: 12325.471999   Valid Acc: 0.6390064916737228
Epoch: 3   Training Cost: 11568.720426   Valid Acc: 0.6446514253457521
Epoch: 4   Training Cost: 10769.321532   Valid Acc: 0.6429579452441434
Epoch: 5   Training Cost: 10320.244269   Valid Acc: 0.6473327688399662
Epoch: 6   Training Cost: 9760.725150   Valid Acc: 0.6542478125882021
Epoch: 7   Training Cost: 9624.371987   Valid Acc: 0.6395709850409258
Epoch: 8   Training Cost: 9228.418078   Valid Acc: 0.6450747953711544
Epoch: 9   Training Cost: 8814.007600   Valid Acc: 0.645780412080158
Epoch: 10  Training Cost: 8514.500385   Valid Acc: 0.650578605701383
Epoch: 11  Training Cost: 8384.574336   Valid Acc: 0.6464860287891617
Epoch: 12  Training Cost: 8291.969328   Valid Acc: 0.6538244425627999
Epoch: 13  Training Cost: 8618.307766   Valid Acc: 0.6354784081287045
Epoch: 14  Training Cost: 8573.792460   Valid Acc: 0.6395709850409258
Epoch: 15  Training Cost: 8331.288759   Valid Acc: 0.6430990685859441
Epoch: 16  Training Cost: 8377.531442   Valid Acc: 0.6395709850409258
Epoch: 17  Training Cost: 8318.644541   Valid Acc: 0.6380186282811177
Epoch: 18  Training Cost: 8223.701837   Valid Acc: 0.6392887383573242
Epoch: 19  Training Cost: 8065.912225   Valid Acc: 0.642111205193339
```

```
k = 50
Epoch: 0   Training Cost: 13367.564623   Valid Acc: 0.6260231442280553
Epoch: 1   Training Cost: 12559.483550   Valid Acc: 0.6370307648885125
Epoch: 2   Training Cost: 11749.929974   Valid Acc: 0.646344905447361
Epoch: 3   Training Cost: 10489.281570   Valid Acc: 0.6563646627152131
Epoch: 4   Training Cost: 9030.786955   Valid Acc: 0.6521309624611911
Epoch: 5   Training Cost: 7635.109044   Valid Acc: 0.6546711826136042
Epoch: 6   Training Cost: 6630.446079   Valid Acc: 0.6549534292972058
Epoch: 7   Training Cost: 5715.416270   Valid Acc: 0.658058142816822
Epoch: 8   Training Cost: 5005.940602   Valid Acc: 0.6566469093988145
Epoch: 9   Training Cost: 4446.672157   Valid Acc: 0.6529777025119955
Epoch: 10  Training Cost: 4321.696236   Valid Acc: 0.6517075924357889
Epoch: 11  Training Cost: 3783.439203   Valid Acc: 0.6512842224103866
Epoch: 12  Training Cost: 3268.921265   Valid Acc: 0.6501552356759808
Epoch: 13  Training Cost: 2883.911183   Valid Acc: 0.6494496189669772
Epoch: 14  Training Cost: 2595.155164   Valid Acc: 0.648461755574372
Epoch: 15  Training Cost: 2460.333509   Valid Acc: 0.6438046852949478
Epoch: 16  Training Cost: 2238.668852   Valid Acc: 0.6438046852949478
Epoch: 17  Training Cost: 2089.497873   Valid Acc: 0.6414055884843353
Epoch: 18  Training Cost: 1921.550576   Valid Acc: 0.6414055884843353
Epoch: 19  Training Cost: 1836.365427   Valid Acc: 0.6385831216483207
```

```
k = 100
Epoch: 0   Training Cost: 13578.797862   Valid Acc: 0.6186847304544172
Epoch: 1   Training Cost: 12617.213044   Valid Acc: 0.6394298616991251
Epoch: 2   Training Cost: 11843.494409   Valid Acc: 0.6462037821055603
Epoch: 3   Training Cost: 10931.233673   Valid Acc: 0.6474738921817669
Epoch: 4   Training Cost: 9758.680793   Valid Acc: 0.6502963590177815
Epoch: 5   Training Cost: 8370.090344   Valid Acc: 0.6522720858029918
Epoch: 6   Training Cost: 6849.006425   Valid Acc: 0.6502963590177815
Epoch: 7   Training Cost: 5374.004409   Valid Acc: 0.6466271521309624
Epoch: 8   Training Cost: 4517.612315   Valid Acc: 0.6470505221563647
Epoch: 9   Training Cost: 3669.655210   Valid Acc: 0.6447925486875529
Epoch: 10  Training Cost: 2883.401753   Valid Acc: 0.645780412080158
Epoch: 11  Training Cost: 2509.992630   Valid Acc: 0.6460626587637596
Epoch: 12  Training Cost: 2295.823674   Valid Acc: 0.643663561953147
Epoch: 13  Training Cost: 1809.090128   Valid Acc: 0.6445103020039514
Epoch: 14  Training Cost: 1424.393585   Valid Acc: 0.6415467118261361
Epoch: 15  Training Cost: 1149.122678   Valid Acc: 0.6411233418007338
Epoch: 16  Training Cost: 996.380292   Valid Acc: 0.6409822184589331
Epoch: 17  Training Cost: 804.938565   Valid Acc: 0.6429579452441434
Epoch: 18  Training Cost: 670.678229   Valid Acc: 0.6419700818515383
Epoch: 19  Training Cost: 561.119216   Valid Acc: 0.6449336720293537
```

```
k = 200
Epoch: 0   Training Cost: 14366.940452   Valid Acc: 0.6186847304544172
Epoch: 1   Training Cost: 12770.313925   Valid Acc: 0.6239062941010444
Epoch: 2   Training Cost: 12373.862065   Valid Acc: 0.6343494213942986
Epoch: 3   Training Cost: 11748.106637   Valid Acc: 0.6414055884843353
Epoch: 4   Training Cost: 10903.792235   Valid Acc: 0.64422805532035
Epoch: 5   Training Cost: 9496.450421   Valid Acc: 0.6510019757267852
Epoch: 6   Training Cost: 8124.282996   Valid Acc: 0.6483206322325713
```

Epoch: 7	Training Cost: 6866.927443	Valid Acc: 0.647897262207169
Epoch: 8	Training Cost: 5778.901812	Valid Acc: 0.6507197290431838
Epoch: 9	Training Cost: 4693.791697	Valid Acc: 0.6490262489415749
Epoch: 10	Training Cost: 4019.181845	Valid Acc: 0.6528365791701948
Epoch: 11	Training Cost: 3487.685218	Valid Acc: 0.6512842224103866
Epoch: 12	Training Cost: 2807.933156	Valid Acc: 0.6517075924357889
Epoch: 13	Training Cost: 2309.527246	Valid Acc: 0.6497318656505786
Epoch: 14	Training Cost: 1876.856798	Valid Acc: 0.6454981653965566
Epoch: 15	Training Cost: 1676.706912	Valid Acc: 0.6481795088907706
Epoch: 16	Training Cost: 1454.263251	Valid Acc: 0.6447925486875529
Epoch: 17	Training Cost: 1181.293573	Valid Acc: 0.6422523285351397
Epoch: 18	Training Cost: 1009.165296	Valid Acc: 0.6449336720293537
Epoch: 19	Training Cost: 838.295993	Valid Acc: 0.6440869319785493

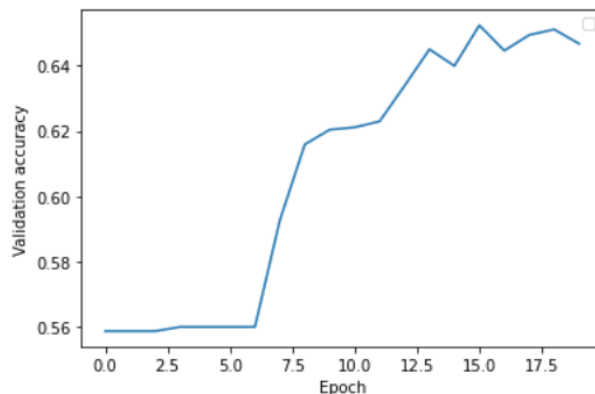
k = 500

Epoch: 0	Training Cost: 24368.246130	Valid Acc: 0.558848433530906
Epoch: 1	Training Cost: 23918.836850	Valid Acc: 0.558848433530906
Epoch: 2	Training Cost: 23918.256949	Valid Acc: 0.5591306802145075
Epoch: 3	Training Cost: 23912.807736	Valid Acc: 0.5589895568727068
Epoch: 4	Training Cost: 23908.001487	Valid Acc: 0.5596951735817104
Epoch: 5	Training Cost: 23906.788272	Valid Acc: 0.5596951735817104
Epoch: 6	Training Cost: 23892.024802	Valid Acc: 0.5599774202653118
Epoch: 7	Training Cost: 23887.345054	Valid Acc: 0.5601185436071127
Epoch: 8	Training Cost: 23849.888311	Valid Acc: 0.5602596669489134
Epoch: 9	Training Cost: 23829.646625	Valid Acc: 0.5623765170759244
Epoch: 10	Training Cost: 21960.133374	Valid Acc: 0.591730172170477
Epoch: 11	Training Cost: 14257.767302	Valid Acc: 0.6148744002257973
Epoch: 12	Training Cost: 13003.340517	Valid Acc: 0.6254586508608524
Epoch: 13	Training Cost: 12499.928222	Valid Acc: 0.6329381879762913
Epoch: 14	Training Cost: 12049.896541	Valid Acc: 0.6428168219023427
Epoch: 15	Training Cost: 11527.275966	Valid Acc: 0.6480383855489698
Epoch: 16	Training Cost: 11045.177431	Valid Acc: 0.648461755574372
Epoch: 17	Training Cost: 10263.309629	Valid Acc: 0.6510019757267852
Epoch: 18	Training Cost: 9845.540332	Valid Acc: 0.6481795088907706
Epoch: 19	Training Cost: 9022.274427	Valid Acc: 0.6460626587637596

k* that has the highest validation accuracy: 500

(c)

- Final accuracy: 0.6669489133502682



Final accuracy: 0.6669489133502682

- In this case, we see the model is overfitting as the number of epochs is increased, i.e., the training objective continue to decrease while the validation objective almost plateaus or sometimes increases. This result indicates that the model is not generalizing to new data well.

Epoch: 0	Training Cost: 24373.000845	Valid Acc: 0.558848433530906
Epoch: 1	Training Cost: 23918.823230	Valid Acc: 0.558848433530906
Epoch: 2	Training Cost: 23919.398136	Valid Acc: 0.558848433530906
Epoch: 3	Training Cost: 23887.815258	Valid Acc: 0.5601185436071127
Epoch: 4	Training Cost: 23872.695071	Valid Acc: 0.5601185436071127
Epoch: 5	Training Cost: 23874.122912	Valid Acc: 0.5601185436071127
Epoch: 6	Training Cost: 23876.257623	Valid Acc: 0.5601185436071127
Epoch: 7	Training Cost: 22129.526071	Valid Acc: 0.5927180355630821
Epoch: 8	Training Cost: 14177.859686	Valid Acc: 0.6158622636184025
Epoch: 9	Training Cost: 13140.201216	Valid Acc: 0.6203782105560259
Epoch: 10	Training Cost: 12842.281717	Valid Acc: 0.6210838272650296
Epoch: 11	Training Cost: 12664.996949	Valid Acc: 0.6229184307084392
Epoch: 12	Training Cost: 12417.470740	Valid Acc: 0.6337849280270956
Epoch: 13	Training Cost: 12045.506487	Valid Acc: 0.6449336720293537
Epoch: 14	Training Cost: 11455.701118	Valid Acc: 0.6398532317245272
Epoch: 15	Training Cost: 10604.218075	Valid Acc: 0.6522720858029918

Epoch: 16	Training Cost: 9545.204411	Valid Acc: 0.6445103020039514
Epoch: 17	Training Cost: 8533.814980	Valid Acc: 0.6493084956251765
Epoch: 18	Training Cost: 7631.424037	Valid Acc: 0.6510019757267852
Epoch: 19	Training Cost: 6600.281940	Valid Acc: 0.6466271521309624
Final accuracy: 0.6669489133502682		

(d)

The most optimal k by training is 10

The most optimal lamda by training is 0.001

The final validation accuracy is 0.6687835167936776

The final test accuracy is 0.6240474174428451

In order to prevent our model from overfitting, which could lead a poor generalization to new data, regularization could be used. Usually the by applying a regularization, the training accuracy might slightly decrease, but the test accuracy should increase. The test accuracy in this run does not have a significant difference from the one without applying a l2 norm, but as increasing the number of epochs, the test accuracy becomes higher.

k = 10, lamda = 0.001

/usr/local/lib/python3.8/dist-packages/torch/nn/functional.py:1967: UserWarning: nn.functional.sigmoid is deprecated. Use torch.sigmoid instead.

warnings.warn("nn.functional.sigmoid is deprecated. Use torch.sigmoid instead.")

Epoch: 0	Training Cost: 13604.553985	Valid Acc: 0.6247530341518487
Epoch: 1	Training Cost: 12988.010158	Valid Acc: 0.6301157211402766
Epoch: 2	Training Cost: 12945.025071	Valid Acc: 0.6398532317245272
Epoch: 3	Training Cost: 12590.679634	Valid Acc: 0.6559412926898109
Epoch: 4	Training Cost: 12513.882364	Valid Acc: 0.6446514253457521
Epoch: 5	Training Cost: 12772.791451	Valid Acc: 0.6562235393734124
Epoch: 6	Training Cost: 12879.023573	Valid Acc: 0.6627152130962461
Epoch: 7	Training Cost: 12416.420479	Valid Acc: 0.6639853231724527
Epoch: 8	Training Cost: 12412.567851	Valid Acc: 0.6628563364380469
Epoch: 9	Training Cost: 12724.521627	Valid Acc: 0.6621507197290432
Epoch: 10	Training Cost: 12396.580826	Valid Acc: 0.6628563364380469
Epoch: 11	Training Cost: 12924.449508	Valid Acc: 0.6641264465142535
Epoch: 12	Training Cost: 13039.563541	Valid Acc: 0.6618684730454417
Epoch: 13	Training Cost: 13758.820187	Valid Acc: 0.6525543324865933
Epoch: 14	Training Cost: 13309.323763	Valid Acc: 0.6637030764888513
Epoch: 15	Training Cost: 12932.605384	Valid Acc: 0.6656788032740615
Epoch: 16	Training Cost: 12934.928771	Valid Acc: 0.6672311600338696
Epoch: 17	Training Cost: 12321.781589	Valid Acc: 0.6625740897544454
Epoch: 18	Training Cost: 11975.575671	Valid Acc: 0.6673722833756703
Epoch: 19	Training Cost: 11889.358619	Valid Acc: 0.6687835167936776

k = 10, lamda = 0.01

Epoch: 0	Training Cost: 13989.469741	Valid Acc: 0.6268698842788597
Epoch: 1	Training Cost: 13027.976699	Valid Acc: 0.6285633643804686
Epoch: 2	Training Cost: 12964.208067	Valid Acc: 0.6295512277730737
Epoch: 3	Training Cost: 12907.418379	Valid Acc: 0.6279988710132656
Epoch: 4	Training Cost: 12870.770241	Valid Acc: 0.6298334744566751
Epoch: 5	Training Cost: 12864.980643	Valid Acc: 0.6279988710132656
Epoch: 6	Training Cost: 12843.213200	Valid Acc: 0.6261642675698561
Epoch: 7	Training Cost: 12818.046209	Valid Acc: 0.6255997742026531
Epoch: 8	Training Cost: 12816.830512	Valid Acc: 0.6253175275190517
Epoch: 9	Training Cost: 12815.999313	Valid Acc: 0.6253175275190517
Epoch: 10	Training Cost: 12815.347511	Valid Acc: 0.6254586508608524
Epoch: 11	Training Cost: 12814.842207	Valid Acc: 0.6255997742026531
Epoch: 12	Training Cost: 12814.444967	Valid Acc: 0.6255997742026531
Epoch: 13	Training Cost: 12814.127462	Valid Acc: 0.6255997742026531
Epoch: 14	Training Cost: 12813.869710	Valid Acc: 0.6257408975444538
Epoch: 15	Training Cost: 12813.657363	Valid Acc: 0.6255997742026531
Epoch: 16	Training Cost: 12813.480214	Valid Acc: 0.6255997742026531
Epoch: 17	Training Cost: 12813.330857	Valid Acc: 0.6255997742026531
Epoch: 18	Training Cost: 12813.203790	Valid Acc: 0.6255997742026531
Epoch: 19	Training Cost: 12813.094609	Valid Acc: 0.6255997742026531

k = 10, lamda = 0.1

Epoch: 0	Training Cost: 14044.918137	Valid Acc: 0.6223539373412362
Epoch: 1	Training Cost: 12933.426137	Valid Acc: 0.6263053909116568
Epoch: 2	Training Cost: 12865.632979	Valid Acc: 0.6255997742026531
Epoch: 3	Training Cost: 12844.897302	Valid Acc: 0.6253175275190517
Epoch: 4	Training Cost: 12835.118620	Valid Acc: 0.6253175275190517

Epoch: 5	Training Cost: 12829.574391	Valid Acc: 0.6253175275190517
Epoch: 6	Training Cost: 12826.067846	Valid Acc: 0.6253175275190517
Epoch: 7	Training Cost: 12823.675237	Valid Acc: 0.6253175275190517
Epoch: 8	Training Cost: 12821.948802	Valid Acc: 0.6255997742026531
Epoch: 9	Training Cost: 12820.649410	Valid Acc: 0.6255997742026531
Epoch: 10	Training Cost: 12819.638415	Valid Acc: 0.6255997742026531
Epoch: 11	Training Cost: 12818.830800	Valid Acc: 0.6255997742026531
Epoch: 12	Training Cost: 12818.171714	Valid Acc: 0.6255997742026531
Epoch: 13	Training Cost: 12817.624254	Valid Acc: 0.6255997742026531
Epoch: 14	Training Cost: 12817.162458	Valid Acc: 0.6255997742026531
Epoch: 15	Training Cost: 12816.768019	Valid Acc: 0.6255997742026531
Epoch: 16	Training Cost: 12816.427401	Valid Acc: 0.6255997742026531
Epoch: 17	Training Cost: 12816.130268	Valid Acc: 0.6255997742026531
Epoch: 18	Training Cost: 12815.869064	Valid Acc: 0.6255997742026531
Epoch: 19	Training Cost: 12815.637469	Valid Acc: 0.6255997742026531

k = 10, lamda = 1

Epoch: 0	Training Cost: 14544.837565	Valid Acc: 0.6237651707592435
Epoch: 1	Training Cost: 13173.135533	Valid Acc: 0.6241885407846458
Epoch: 2	Training Cost: 13023.251335	Valid Acc: 0.6255997742026531
Epoch: 3	Training Cost: 12962.911322	Valid Acc: 0.6255997742026531
Epoch: 4	Training Cost: 12929.546745	Valid Acc: 0.6257408975444538
Epoch: 5	Training Cost: 12908.251265	Valid Acc: 0.6257408975444538
Epoch: 6	Training Cost: 12893.454686	Valid Acc: 0.6255997742026531
Epoch: 7	Training Cost: 12882.567987	Valid Acc: 0.6255997742026531
Epoch: 8	Training Cost: 12874.219548	Valid Acc: 0.6255997742026531
Epoch: 9	Training Cost: 12867.613520	Valid Acc: 0.6255997742026531
Epoch: 10	Training Cost: 12862.256150	Valid Acc: 0.6255997742026531
Epoch: 11	Training Cost: 12857.824370	Valid Acc: 0.6255997742026531
Epoch: 12	Training Cost: 12854.097992	Valid Acc: 0.6255997742026531
Epoch: 13	Training Cost: 12850.921426	Valid Acc: 0.6255997742026531
Epoch: 14	Training Cost: 12848.181612	Valid Acc: 0.6255997742026531
Epoch: 15	Training Cost: 12845.794967	Valid Acc: 0.6255997742026531
Epoch: 16	Training Cost: 12843.697396	Valid Acc: 0.6255997742026531
Epoch: 17	Training Cost: 12841.839737	Valid Acc: 0.6255997742026531
Epoch: 18	Training Cost: 12840.183112	Valid Acc: 0.6255997742026531
Epoch: 19	Training Cost: 12838.696937	Valid Acc: 0.6255997742026531

k = 50, lamda = 0.001

Epoch: 0	Training Cost: 13764.544332	Valid Acc: 0.6271521309624611
Epoch: 1	Training Cost: 13082.121455	Valid Acc: 0.6366073948631104
Epoch: 2	Training Cost: 12970.152971	Valid Acc: 0.65001411233418
Epoch: 3	Training Cost: 12540.447658	Valid Acc: 0.6528365791701948
Epoch: 4	Training Cost: 12131.002307	Valid Acc: 0.657493649449619
Epoch: 5	Training Cost: 11219.993332	Valid Acc: 0.6597516229184307
Epoch: 6	Training Cost: 11296.617368	Valid Acc: 0.6589048828676263
Epoch: 7	Training Cost: 11427.659724	Valid Acc: 0.6586226361840248
Epoch: 8	Training Cost: 11051.410978	Valid Acc: 0.6546711826136042
Epoch: 9	Training Cost: 10859.715609	Valid Acc: 0.6510019757267852
Epoch: 10	Training Cost: 10384.077904	Valid Acc: 0.6531188258537962
Epoch: 11	Training Cost: 10678.621864	Valid Acc: 0.6459215354219587
Epoch: 12	Training Cost: 10664.623538	Valid Acc: 0.647897262207169
Epoch: 13	Training Cost: 10896.947116	Valid Acc: 0.6525543324865933
Epoch: 14	Training Cost: 10852.960533	Valid Acc: 0.6519898391193903
Epoch: 15	Training Cost: 10932.786448	Valid Acc: 0.6471916454981654
Epoch: 16	Training Cost: 10805.907999	Valid Acc: 0.6486028789161727
Epoch: 17	Training Cost: 10955.101905	Valid Acc: 0.6532599491955969
Epoch: 18	Training Cost: 10452.524348	Valid Acc: 0.6512842224103866
Epoch: 19	Training Cost: 10491.173726	Valid Acc: 0.64422805532035

k = 50, lamda = 0.01

Epoch: 0	Training Cost: 14401.656200	Valid Acc: 0.6223539373412362
Epoch: 1	Training Cost: 13228.588785	Valid Acc: 0.6271521309624611
Epoch: 2	Training Cost: 13056.727213	Valid Acc: 0.6291278577476714
Epoch: 3	Training Cost: 12925.190173	Valid Acc: 0.6271521309624611
Epoch: 4	Training Cost: 12873.763721	Valid Acc: 0.6264465142534575
Epoch: 5	Training Cost: 12847.869715	Valid Acc: 0.6258820208862546
Epoch: 6	Training Cost: 12840.709017	Valid Acc: 0.6261642675698561
Epoch: 7	Training Cost: 12835.512442	Valid Acc: 0.6263053909116568
Epoch: 8	Training Cost: 12831.596162	Valid Acc: 0.6261642675698561
Epoch: 9	Training Cost: 12828.600953	Valid Acc: 0.6261642675698561
Epoch: 10	Training Cost: 12826.264028	Valid Acc: 0.6257408975444538
Epoch: 11	Training Cost: 12824.405930	Valid Acc: 0.6257408975444538
Epoch: 12	Training Cost: 12822.904068	Valid Acc: 0.6257408975444538
Epoch: 13	Training Cost: 12821.672321	Valid Acc: 0.6257408975444538
Epoch: 14	Training Cost: 12820.649379	Valid Acc: 0.6260231442280553
Epoch: 15	Training Cost: 12819.790464	Valid Acc: 0.6263053909116568
Epoch: 16	Training Cost: 12819.062109	Valid Acc: 0.6263053909116568
Epoch: 17	Training Cost: 12818.438944	Valid Acc: 0.6264465142534575
Epoch: 18	Training Cost: 12817.901324	Valid Acc: 0.6260231442280553
Epoch: 19	Training Cost: 12817.434281	Valid Acc: 0.6260231442280553

k = 50, lamda = 0.1

Epoch: 0	Training Cost: 14579.913880	Valid Acc: 0.6222128139994355
Epoch: 1	Training Cost: 13101.540311	Valid Acc: 0.624611910810048
Epoch: 2	Training Cost: 12963.886173	Valid Acc: 0.6254586508608524

Epoch: 3	Training Cost: 12914.943567	Valid Acc: 0.6247530341518487
Epoch: 4	Training Cost: 12889.629398	Valid Acc: 0.6253175275190517
Epoch: 5	Training Cost: 12874.194666	Valid Acc: 0.6255997742026531
Epoch: 6	Training Cost: 12863.831898	Valid Acc: 0.6255997742026531
Epoch: 7	Training Cost: 12856.406624	Valid Acc: 0.625176404177251
Epoch: 8	Training Cost: 12850.829345	Valid Acc: 0.625176404177251
Epoch: 9	Training Cost: 12846.488241	Valid Acc: 0.6253175275190517
Epoch: 10	Training Cost: 12843.014386	Valid Acc: 0.6253175275190517
Epoch: 11	Training Cost: 12840.171877	Valid Acc: 0.6253175275190517
Epoch: 12	Training Cost: 12837.803163	Valid Acc: 0.6253175275190517
Epoch: 13	Training Cost: 12835.799228	Valid Acc: 0.6253175275190517
Epoch: 14	Training Cost: 12834.081989	Valid Acc: 0.6253175275190517
Epoch: 15	Training Cost: 12832.593975	Valid Acc: 0.6253175275190517
Epoch: 16	Training Cost: 12831.292223	Valid Acc: 0.6253175275190517
Epoch: 17	Training Cost: 12830.143887	Valid Acc: 0.6253175275190517
Epoch: 18	Training Cost: 12829.123530	Valid Acc: 0.6253175275190517
Epoch: 19	Training Cost: 12828.210622	Valid Acc: 0.6253175275190517

k = 50, lamda = 1

Epoch: 0	Training Cost: 16273.919659	Valid Acc: 0.624611910810048
Epoch: 1	Training Cost: 13655.922442	Valid Acc: 0.6244707874682472
Epoch: 2	Training Cost: 13345.255767	Valid Acc: 0.6247530341518487
Epoch: 3	Training Cost: 13215.608627	Valid Acc: 0.6253175275190517
Epoch: 4	Training Cost: 13141.107831	Valid Acc: 0.6253175275190517
Epoch: 5	Training Cost: 13091.757727	Valid Acc: 0.6254586508608524
Epoch: 6	Training Cost: 13056.283835	Valid Acc: 0.6254586508608524
Epoch: 7	Training Cost: 13029.376938	Valid Acc: 0.6254586508608524
Epoch: 8	Training Cost: 13008.173580	Valid Acc: 0.6254586508608524
Epoch: 9	Training Cost: 12990.978823	Valid Acc: 0.6257408975444538
Epoch: 10	Training Cost: 12976.720781	Valid Acc: 0.6257408975444538
Epoch: 11	Training Cost: 12964.684520	Valid Acc: 0.6257408975444538
Epoch: 12	Training Cost: 12954.373883	Valid Acc: 0.6257408975444538
Epoch: 13	Training Cost: 12945.432181	Valid Acc: 0.6257408975444538
Epoch: 14	Training Cost: 12937.596867	Valid Acc: 0.6257408975444538
Epoch: 15	Training Cost: 12930.669351	Valid Acc: 0.6257408975444538
Epoch: 16	Training Cost: 12924.496473	Valid Acc: 0.6257408975444538
Epoch: 17	Training Cost: 12918.957936	Valid Acc: 0.6257408975444538
Epoch: 18	Training Cost: 12913.959182	Valid Acc: 0.6257408975444538
Epoch: 19	Training Cost: 12909.422652	Valid Acc: 0.6257408975444538

k = 100, lamda = 0.001

Epoch: 0	Training Cost: 13903.676102	Valid Acc: 0.6285633643804686
Epoch: 1	Training Cost: 13128.733945	Valid Acc: 0.62884561106407
Epoch: 2	Training Cost: 12778.175683	Valid Acc: 0.6459215354219587
Epoch: 3	Training Cost: 12671.469031	Valid Acc: 0.652695455828394
Epoch: 4	Training Cost: 12166.203481	Valid Acc: 0.6562235393734124
Epoch: 5	Training Cost: 11672.174234	Valid Acc: 0.6584815128422241
Epoch: 6	Training Cost: 11019.925485	Valid Acc: 0.6548123059554051
Epoch: 7	Training Cost: 10326.486762	Valid Acc: 0.6539655659046006
Epoch: 8	Training Cost: 9943.118282	Valid Acc: 0.6531188258537962
Epoch: 9	Training Cost: 9631.074953	Valid Acc: 0.6567880327406153
Epoch: 10	Training Cost: 9152.010019	Valid Acc: 0.6510019757267852
Epoch: 11	Training Cost: 9285.032278	Valid Acc: 0.6456392887383573
Epoch: 12	Training Cost: 9446.532644	Valid Acc: 0.6510019757267852
Epoch: 13	Training Cost: 9173.821673	Valid Acc: 0.6508608523849845
Epoch: 14	Training Cost: 8649.148958	Valid Acc: 0.6450747953711544
Epoch: 15	Training Cost: 8360.051357	Valid Acc: 0.6471916454981654
Epoch: 16	Training Cost: 8284.576392	Valid Acc: 0.6486028789161727
Epoch: 17	Training Cost: 8627.746399	Valid Acc: 0.6429579452441434
Epoch: 18	Training Cost: 8422.573837	Valid Acc: 0.6446514253457521
Epoch: 19	Training Cost: 8038.689483	Valid Acc: 0.6446514253457521

k = 100, lamda = 0.01

Epoch: 0	Training Cost: 14535.125036	Valid Acc: 0.6151566469093989
Epoch: 1	Training Cost: 13142.947630	Valid Acc: 0.6215071972904318
Epoch: 2	Training Cost: 12988.429257	Valid Acc: 0.6260231442280553
Epoch: 3	Training Cost: 12931.392753	Valid Acc: 0.6253175275190517
Epoch: 4	Training Cost: 12900.592100	Valid Acc: 0.6254586508608524
Epoch: 5	Training Cost: 12880.877625	Valid Acc: 0.6247530341518487
Epoch: 6	Training Cost: 12867.270029	Valid Acc: 0.6250352808354502
Epoch: 7	Training Cost: 12857.442277	Valid Acc: 0.6257408975444538
Epoch: 8	Training Cost: 12850.096005	Valid Acc: 0.6258820208862546
Epoch: 9	Training Cost: 12844.451657	Valid Acc: 0.6258820208862546
Epoch: 10	Training Cost: 12840.016961	Valid Acc: 0.6263053909116568
Epoch: 11	Training Cost: 12836.467564	Valid Acc: 0.6263053909116568
Epoch: 12	Training Cost: 12833.581809	Valid Acc: 0.6264465142534575
Epoch: 13	Training Cost: 12831.203630	Valid Acc: 0.6260231442280553
Epoch: 14	Training Cost: 12829.220379	Valid Acc: 0.6258820208862546
Epoch: 15	Training Cost: 12827.549085	Valid Acc: 0.6260231442280553
Epoch: 16	Training Cost: 12826.127371	Valid Acc: 0.6257408975444538
Epoch: 17	Training Cost: 12824.907536	Valid Acc: 0.6257408975444538
Epoch: 18	Training Cost: 12823.852798	Valid Acc: 0.6257408975444538
Epoch: 19	Training Cost: 12822.934527	Valid Acc: 0.6257408975444538

k = 100, lamda = 0.1

Epoch: 0	Training Cost: 15193.738394	Valid Acc: 0.6181202370872142
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Epoch: 1	Training Cost: 13249.789810	Valid Acc: 0.6254586508608524
Epoch: 2	Training Cost: 13051.895611	Valid Acc: 0.6244707874682472
Epoch: 3	Training Cost: 12979.270390	Valid Acc: 0.6253175275190517
Epoch: 4	Training Cost: 12940.858694	Valid Acc: 0.6255997742026531
Epoch: 5	Training Cost: 12916.970671	Valid Acc: 0.625176404177251
Epoch: 6	Training Cost: 12900.654992	Valid Acc: 0.6247530341518487
Epoch: 7	Training Cost: 12888.790898	Valid Acc: 0.625176404177251
Epoch: 8	Training Cost: 12879.766774	Valid Acc: 0.6253175275190517
Epoch: 9	Training Cost: 12872.666524	Valid Acc: 0.6255997742026531
Epoch: 10	Training Cost: 12866.930418	Valid Acc: 0.6255997742026531
Epoch: 11	Training Cost: 12862.197518	Valid Acc: 0.6255997742026531
Epoch: 12	Training Cost: 12858.224242	Valid Acc: 0.6255997742026531
Epoch: 13	Training Cost: 12854.840196	Valid Acc: 0.625176404177251
Epoch: 14	Training Cost: 12851.922476	Valid Acc: 0.625176404177251
Epoch: 15	Training Cost: 12849.380234	Valid Acc: 0.625176404177251
Epoch: 16	Training Cost: 12847.145093	Valid Acc: 0.625176404177251
Epoch: 17	Training Cost: 12845.164182	Valid Acc: 0.6253175275190517
Epoch: 18	Training Cost: 12843.396263	Valid Acc: 0.6253175275190517
Epoch: 19	Training Cost: 12841.808496	Valid Acc: 0.6253175275190517

k = 100, lamda = 1

Epoch: 0	Training Cost: 18423.518444	Valid Acc: 0.6241885407846458
Epoch: 1	Training Cost: 14088.664882	Valid Acc: 0.6250352808354502
Epoch: 2	Training Cost: 13616.207748	Valid Acc: 0.6240474174428451
Epoch: 3	Training Cost: 13425.311029	Valid Acc: 0.6248941574936494
Epoch: 4	Training Cost: 13316.480926	Valid Acc: 0.6253175275190517
Epoch: 5	Training Cost: 13244.438775	Valid Acc: 0.6253175275190517
Epoch: 6	Training Cost: 13192.544701	Valid Acc: 0.6253175275190517
Epoch: 7	Training Cost: 13153.053364	Valid Acc: 0.6253175275190517
Epoch: 8	Training Cost: 13121.815726	Valid Acc: 0.6254586508608524
Epoch: 9	Training Cost: 13096.382575	Valid Acc: 0.6254586508608524
Epoch: 10	Training Cost: 13075.207252	Valid Acc: 0.6250352808354502
Epoch: 11	Training Cost: 13057.258397	Valid Acc: 0.6250352808354502
Epoch: 12	Training Cost: 13041.822127	Valid Acc: 0.6254586508608524
Epoch: 13	Training Cost: 13028.382735	Valid Acc: 0.6254586508608524
Epoch: 14	Training Cost: 13016.561346	Valid Acc: 0.6254586508608524
Epoch: 15	Training Cost: 13006.069670	Valid Acc: 0.6254586508608524
Epoch: 16	Training Cost: 12996.687164	Valid Acc: 0.6254586508608524
Epoch: 17	Training Cost: 12988.239897	Valid Acc: 0.6257408975444538
Epoch: 18	Training Cost: 12980.589205	Valid Acc: 0.6257408975444538
Epoch: 19	Training Cost: 12973.623016	Valid Acc: 0.6257408975444538

k = 200, lamda = 0.001

Epoch: 0	Training Cost: 14873.723299	Valid Acc: 0.6137454134913914
Epoch: 1	Training Cost: 13216.165992	Valid Acc: 0.6227773073666384
Epoch: 2	Training Cost: 12938.903003	Valid Acc: 0.6343494213942986
Epoch: 3	Training Cost: 12649.163668	Valid Acc: 0.646344905447361
Epoch: 4	Training Cost: 12628.113613	Valid Acc: 0.6476150155235676
Epoch: 5	Training Cost: 12192.551355	Valid Acc: 0.6591871295512278
Epoch: 6	Training Cost: 11586.631432	Valid Acc: 0.66539655659046
Epoch: 7	Training Cost: 11041.058929	Valid Acc: 0.6639853231724527
Epoch: 8	Training Cost: 10637.705423	Valid Acc: 0.6583403895004234
Epoch: 9	Training Cost: 10520.380262	Valid Acc: 0.6542478125882021
Epoch: 10	Training Cost: 10211.261629	Valid Acc: 0.6538244425627999
Epoch: 11	Training Cost: 9906.411165	Valid Acc: 0.6584815128422241
Epoch: 12	Training Cost: 9433.584792	Valid Acc: 0.6515664690939882
Epoch: 13	Training Cost: 9051.264386	Valid Acc: 0.6535421958791984
Epoch: 14	Training Cost: 8517.011127	Valid Acc: 0.6583403895004234
Epoch: 15	Training Cost: 8088.652272	Valid Acc: 0.6480383855489698
Epoch: 16	Training Cost: 7741.638144	Valid Acc: 0.6467682754727632
Epoch: 17	Training Cost: 7678.225612	Valid Acc: 0.6488851255997742
Epoch: 18	Training Cost: 7288.261469	Valid Acc: 0.6488851255997742
Epoch: 19	Training Cost: 7143.382435	Valid Acc: 0.6476150155235676

k = 200, lamda = 0.01

Epoch: 0	Training Cost: 15694.658957	Valid Acc: 0.6069714930849562
Epoch: 1	Training Cost: 13313.154707	Valid Acc: 0.6199548405306238
Epoch: 2	Training Cost: 13097.934366	Valid Acc: 0.6213660739486311
Epoch: 3	Training Cost: 13012.393626	Valid Acc: 0.6248941574936494
Epoch: 4	Training Cost: 12963.755865	Valid Acc: 0.6265876375952583
Epoch: 5	Training Cost: 12931.863822	Valid Acc: 0.6255997742026531
Epoch: 6	Training Cost: 12909.471412	Valid Acc: 0.6257408975444538
Epoch: 7	Training Cost: 12893.050905	Valid Acc: 0.6253175275190517
Epoch: 8	Training Cost: 12880.610977	Valid Acc: 0.6253175275190517
Epoch: 9	Training Cost: 12870.940319	Valid Acc: 0.6250352808354502
Epoch: 10	Training Cost: 12863.263501	Valid Acc: 0.6255997742026531
Epoch: 11	Training Cost: 12857.062762	Valid Acc: 0.6255997742026531
Epoch: 12	Training Cost: 12851.980589	Valid Acc: 0.6254586508608524
Epoch: 13	Training Cost: 12847.761683	Valid Acc: 0.6260231442280553
Epoch: 14	Training Cost: 12844.220491	Valid Acc: 0.6260231442280553
Epoch: 15	Training Cost: 12841.218779	Valid Acc: 0.6260231442280553
Epoch: 16	Training Cost: 12838.651603	Valid Acc: 0.6264465142534575
Epoch: 17	Training Cost: 12836.438156	Valid Acc: 0.6264465142534575
Epoch: 18	Training Cost: 12834.515942	Valid Acc: 0.6264465142534575
Epoch: 19	Training Cost: 12832.835431	Valid Acc: 0.6264465142534575

k = 200, lamda = 0.1

Epoch: 0	Training Cost:	16540.366554	Valid Acc:	0.6161445103020039
Epoch: 1	Training Cost:	13503.591344	Valid Acc:	0.6233418007338414
Epoch: 2	Training Cost:	13195.940441	Valid Acc:	0.6243296641264465
Epoch: 3	Training Cost:	13083.563799	Valid Acc:	0.6240474174428451
Epoch: 4	Training Cost:	13023.968266	Valid Acc:	0.6248941574936494
Epoch: 5	Training Cost:	12986.640826	Valid Acc:	0.6247530341518487
Epoch: 6	Training Cost:	12960.935200	Valid Acc:	0.625176404177251
Epoch: 7	Training Cost:	12942.092786	Valid Acc:	0.625176404177251
Epoch: 8	Training Cost:	12927.653074	Valid Acc:	0.6250352808354502
Epoch: 9	Training Cost:	12916.213652	Valid Acc:	0.6253175275190517
Epoch: 10	Training Cost:	12906.913592	Valid Acc:	0.624611910810048
Epoch: 11	Training Cost:	12899.195191	Valid Acc:	0.6248941574936494
Epoch: 12	Training Cost:	12892.680309	Valid Acc:	0.6248941574936494
Epoch: 13	Training Cost:	12887.103797	Valid Acc:	0.6250352808354502
Epoch: 14	Training Cost:	12882.273296	Valid Acc:	0.6253175275190517
Epoch: 15	Training Cost:	12878.046052	Valid Acc:	0.6253175275190517
Epoch: 16	Training Cost:	12874.313943	Valid Acc:	0.6254586508608524
Epoch: 17	Training Cost:	12870.993576	Valid Acc:	0.6257408975444538
Epoch: 18	Training Cost:	12868.019343	Valid Acc:	0.6257408975444538
Epoch: 19	Training Cost:	12865.338888	Valid Acc:	0.6257408975444538

k = 200, lamda = 1

Epoch: 0	Training Cost:	23834.106648	Valid Acc:	0.6222128139994355
Epoch: 1	Training Cost:	15025.931337	Valid Acc:	0.6248941574936494
Epoch: 2	Training Cost:	14101.423077	Valid Acc:	0.6248941574936494
Epoch: 3	Training Cost:	13777.031594	Valid Acc:	0.6243296641264465
Epoch: 4	Training Cost:	13601.303319	Valid Acc:	0.6250352808354502
Epoch: 5	Training Cost:	13487.904941	Valid Acc:	0.6253175275190517
Epoch: 6	Training Cost:	13407.409390	Valid Acc:	0.6248941574936494
Epoch: 7	Training Cost:	13346.706939	Valid Acc:	0.6253175275190517
Epoch: 8	Training Cost:	13298.968299	Valid Acc:	0.6253175275190517
Epoch: 9	Training Cost:	13260.243141	Valid Acc:	0.6253175275190517
Epoch: 10	Training Cost:	13228.076851	Valid Acc:	0.6253175275190517
Epoch: 11	Training Cost:	13200.847851	Valid Acc:	0.6253175275190517
Epoch: 12	Training Cost:	13177.443023	Valid Acc:	0.6253175275190517
Epoch: 13	Training Cost:	13157.068751	Valid Acc:	0.6253175275190517
Epoch: 14	Training Cost:	13139.141304	Valid Acc:	0.6253175275190517
Epoch: 15	Training Cost:	13123.222650	Valid Acc:	0.6254586508608524
Epoch: 16	Training Cost:	13108.975011	Valid Acc:	0.6254586508608524
Epoch: 17	Training Cost:	13096.134502	Valid Acc:	0.6254586508608524
Epoch: 18	Training Cost:	13084.492124	Valid Acc:	0.6254586508608524
Epoch: 19	Training Cost:	13073.879802	Valid Acc:	0.6250352808354502

k = 500, lamda = 0.001

Epoch: 0	Training Cost:	25242.173208	Valid Acc:	0.5587073101891052
Epoch: 1	Training Cost:	22620.944692	Valid Acc:	0.5973751058425063
Epoch: 2	Training Cost:	14289.661630	Valid Acc:	0.6151566469093989
Epoch: 3	Training Cost:	13349.095016	Valid Acc:	0.6161445103020039
Epoch: 4	Training Cost:	13051.311334	Valid Acc:	0.6230595540502399
Epoch: 5	Training Cost:	12832.334371	Valid Acc:	0.6336438046852949
Epoch: 6	Training Cost:	12776.944757	Valid Acc:	0.6428168219023427
Epoch: 7	Training Cost:	12795.923084	Valid Acc:	0.6566469093988145
Epoch: 8	Training Cost:	12684.772638	Valid Acc:	0.6562235393734124
Epoch: 9	Training Cost:	12144.100255	Valid Acc:	0.6560824160316117
Epoch: 10	Training Cost:	11427.278742	Valid Acc:	0.6577758961332204
Epoch: 11	Training Cost:	10913.364696	Valid Acc:	0.6587637595258256
Epoch: 12	Training Cost:	10499.887429	Valid Acc:	0.6562235393734124
Epoch: 13	Training Cost:	10013.944655	Valid Acc:	0.6543889359300028
Epoch: 14	Training Cost:	9631.514111	Valid Acc:	0.6541066892464014
Epoch: 15	Training Cost:	9099.166863	Valid Acc:	0.6518487157775896
Epoch: 16	Training Cost:	8541.610106	Valid Acc:	0.6524132091447925
Epoch: 17	Training Cost:	7980.928732	Valid Acc:	0.6549534292972058
Epoch: 18	Training Cost:	7454.898663	Valid Acc:	0.6508608523849845
Epoch: 19	Training Cost:	7032.840826	Valid Acc:	0.6486028789161727

k = 500, lamda = 0.01

Epoch: 0	Training Cost:	21935.814538	Valid Acc:	0.5880609652836579
Epoch: 1	Training Cost:	14255.203219	Valid Acc:	0.6072537397685577
Epoch: 2	Training Cost:	13503.714246	Valid Acc:	0.6174146203782106
Epoch: 3	Training Cost:	13279.469209	Valid Acc:	0.6217894439740334
Epoch: 4	Training Cost:	13164.195032	Valid Acc:	0.6210838272650296
Epoch: 5	Training Cost:	13090.545388	Valid Acc:	0.6226361840248377
Epoch: 6	Training Cost:	13039.192510	Valid Acc:	0.6240474174428451
Epoch: 7	Training Cost:	13001.602773	Valid Acc:	0.6261642675698561
Epoch: 8	Training Cost:	12973.114220	Valid Acc:	0.6270110076206604
Epoch: 9	Training Cost:	12950.928182	Valid Acc:	0.6264465142534575
Epoch: 10	Training Cost:	12933.270094	Valid Acc:	0.6258820208862546
Epoch: 11	Training Cost:	12918.963415	Valid Acc:	0.6263053909116568
Epoch: 12	Training Cost:	12907.198307	Valid Acc:	0.6253175275190517
Epoch: 13	Training Cost:	12897.400363	Valid Acc:	0.6253175275190517
Epoch: 14	Training Cost:	12889.150023	Valid Acc:	0.6255997742026531
Epoch: 15	Training Cost:	12882.135179	Valid Acc:	0.6247530341518487
Epoch: 16	Training Cost:	12876.118921	Valid Acc:	0.6253175275190517
Epoch: 17	Training Cost:	12870.918639	Valid Acc:	0.6254586508608524
Epoch: 18	Training Cost:	12866.391176	Valid Acc:	0.6253175275190517
Epoch: 19	Training Cost:	12862.423830	Valid Acc:	0.6253175275190517

k = 500, lamda = 0.1

Epoch: 0	Training Cost: 21142.725251	Valid Acc: 0.6038667795653401
Epoch: 1	Training Cost: 14280.472365	Valid Acc: 0.617696867061812
Epoch: 2	Training Cost: 13574.415931	Valid Acc: 0.6203782105560259
Epoch: 3	Training Cost: 13342.322737	Valid Acc: 0.6230595540502399
Epoch: 4	Training Cost: 13224.947878	Valid Acc: 0.6239062941010444
Epoch: 5	Training Cost: 13153.006286	Valid Acc: 0.6250352808354502
Epoch: 6	Training Cost: 13103.981169	Valid Acc: 0.6237651707592435
Epoch: 7	Training Cost: 13068.229745	Valid Acc: 0.6248941574936494
Epoch: 8	Training Cost: 13040.893955	Valid Acc: 0.6250352808354502
Epoch: 9	Training Cost: 13019.250265	Valid Acc: 0.6257408975444538
Epoch: 10	Training Cost: 13001.645705	Valid Acc: 0.6258820208862546
Epoch: 11	Training Cost: 12987.016619	Valid Acc: 0.6254586508608524
Epoch: 12	Training Cost: 12974.649017	Valid Acc: 0.6258820208862546
Epoch: 13	Training Cost: 12964.041693	Valid Acc: 0.6258820208862546
Epoch: 14	Training Cost: 12954.832877	Valid Acc: 0.6258820208862546
Epoch: 15	Training Cost: 12946.755951	Valid Acc: 0.6258820208862546
Epoch: 16	Training Cost: 12939.607881	Valid Acc: 0.6258820208862546
Epoch: 17	Training Cost: 12933.232470	Valid Acc: 0.6258820208862546
Epoch: 18	Training Cost: 12927.507643	Valid Acc: 0.6258820208862546
Epoch: 19	Training Cost: 12922.334964	Valid Acc: 0.6257408975444538

k = 500, lamda = 1

Epoch: 0	Training Cost: 51851.288949	Valid Acc: 0.61346316680779
Epoch: 1	Training Cost: 26692.154918	Valid Acc: 0.6178379904036128
Epoch: 2	Training Cost: 17386.787986	Valid Acc: 0.6229184307084392
Epoch: 3	Training Cost: 15271.811386	Valid Acc: 0.6254586508608524
Epoch: 4	Training Cost: 14586.106762	Valid Acc: 0.6248941574936494
Epoch: 5	Training Cost: 14239.281098	Valid Acc: 0.624611910810048
Epoch: 6	Training Cost: 14024.382191	Valid Acc: 0.6248941574936494
Epoch: 7	Training Cost: 13875.847622	Valid Acc: 0.6240474174428451
Epoch: 8	Training Cost: 13765.902523	Valid Acc: 0.6243296641264465
Epoch: 9	Training Cost: 13680.598873	Valid Acc: 0.6247530341518487
Epoch: 10	Training Cost: 13612.096655	Valid Acc: 0.6250352808354502
Epoch: 11	Training Cost: 13555.626155	Valid Acc: 0.6250352808354502
Epoch: 12	Training Cost: 13508.104261	Valid Acc: 0.6250352808354502
Epoch: 13	Training Cost: 13467.439242	Valid Acc: 0.6248941574936494
Epoch: 14	Training Cost: 13432.162528	Valid Acc: 0.6248941574936494
Epoch: 15	Training Cost: 13401.203145	Valid Acc: 0.6248941574936494
Epoch: 16	Training Cost: 13373.766836	Valid Acc: 0.6248941574936494
Epoch: 17	Training Cost: 13349.248204	Valid Acc: 0.6248941574936494
Epoch: 18	Training Cost: 13327.173743	Valid Acc: 0.6253175275190517
Epoch: 19	Training Cost: 13307.175883	Valid Acc: 0.6253175275190517