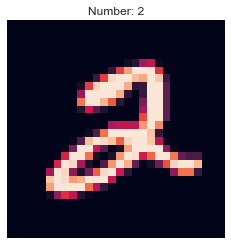
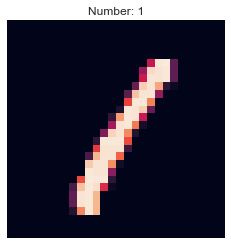
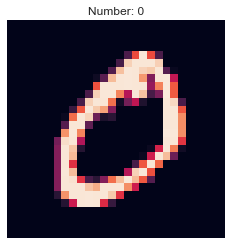
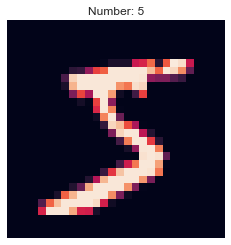
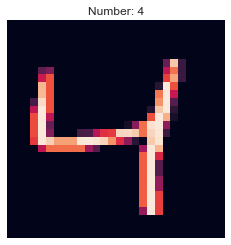
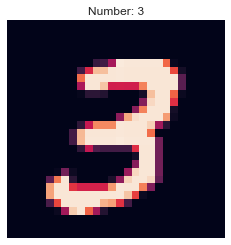
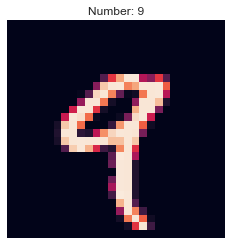
Assignment 1: Dimensionality Reduction using PCA

Display each digit.







Use PCA to retrieve the principal component and output their *explained variance ratio*

*First Principal Component:*

*[ 1.56732868e-17 3.07855956e-19 -4.21453962e-19 -9.99412993e-20*

*-9.82042876e-21 1.92127580e-19 -5.05407662e-22 -6.02948903e-21*

*-2.27492997e-22 4.47828676e-23 -1.49948754e-24 0.00000000e+00*

*-9.45607456e-07 -3.72372523e-06 -1.83966299e-06 -7.66526245e-08*

*0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00*

*0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00*

*0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00*

*0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00*

*2.16821229e-07 4.29486387e-07 4.87705357e-06 1.65228560e-05*

*2.20358936e-05 3.88800851e-05 7.40593155e-05 8.83226978e-05*

*8.08470440e-05 8.95669382e-05 1.06174446e-04 7.93583533e-05*

*3.60808519e-05 3.08090913e-05 2.39080158e-05 3.64600133e-06*

*-2.94150493e-06 1.88461665e-06 1.14902285e-06 4.83369710e-07*

*0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00*

*0.00000000e+00 0.00000000e+00 1.71353699e-06 9.42410580e-07*

*3.40969919e-06 4.85814042e-08 2.87487138e-05 7.30557518e-05*

*1.77420835e-04 3.68521463e-04 5.75864297e-04 9.40411884e-04*

*1.45561381e-03 2.13480950e-03 2.64498178e-03 2.75302713e-03*

*2.62854198e-03 2.16715089e-03 1.44466762e-03 9.12320245e-04*

*5.35466205e-04 2.34552216e-04 1.03779033e-04 3.08899803e-05*

*8.67720151e-06 3.42198250e-06 0.00000000e+00 0.00000000e+00*

*0.00000000e+00 0.00000000e+00 2.28564391e-06 6.83062025e-06*

*1.48465342e-05 6.33102450e-05 1.05236408e-04 2.19779578e-04*

*5.18590872e-04 1.08767935e-03 1.93459928e-03 3.21325488e-03*

*5.00337591e-03 7.16009087e-03 9.07709859e-03 1.01293066e-02*

*9.60086014e-03 7.59327647e-03 5.54863138e-03 3.69639674e-03*

*2.30887171e-03 1.13276796e-03 5.63563755e-04 1.78020346e-04*

*2.80283620e-05 6.45206711e-07 -3.63076343e-06 0.00000000e+00*

*0.00000000e+00 1.45371051e-07 -4.28687510e-06 1.40903373e-05*

*4.95237201e-05 1.85108868e-04 4.80499017e-04 1.09255234e-03*

*2.47599696e-03 4.97085183e-03 8.58294386e-03 1.34622399e-02*

*1.89890979e-02 2.44322687e-02 2.81797754e-02 3.10833258e-02*

*3.08986917e-02 2.66576440e-02 2.09677744e-02 1.47269308e-02*

*8.93260547e-03 5.00854419e-03 2.46376406e-03 9.79980720e-04*

*2.58405352e-04 1.19280789e-05 -1.04261875e-05 -2.84063193e-06*

*0.00000000e+00 -1.89008408e-09 3.48873563e-06 1.53630521e-05*

*2.00934639e-04 6.98160779e-04 1.61130299e-03 3.52514539e-03*

*7.25709766e-03 1.37836726e-02 2.30665995e-02 3.47044178e-02*

*4.57383448e-02 5.28406351e-02 5.54862742e-02 5.55295460e-02*

*5.47762325e-02 5.18737420e-02 4.59853770e-02 3.70493801e-02*

*2.57592904e-02 1.55629338e-02 7.94935161e-03 3.22164347e-03*

*8.99326268e-04 1.47247782e-05 -7.41567944e-06 -4.86563477e-06*

*0.00000000e+00 -9.84661010e-08 -4.10558964e-06 2.55719164e-05*

*4.45050893e-04 1.32811190e-03 2.85082621e-03 6.49568917e-03*

*1.33209679e-02 2.53026024e-02 4.15677256e-02 5.88213320e-02*

*6.95737622e-02 6.99829059e-02 6.26497702e-02 5.47823420e-02*

*5.21710799e-02 5.56994452e-02 5.94980422e-02 5.70615073e-02*

*4.66469580e-02 3.10746374e-02 1.62265490e-02 6.21806362e-03*

*1.45834337e-03 2.79668926e-05 -5.36767518e-05 -1.93042989e-05*

*-5.46736745e-07 -8.73905286e-06 -3.04724883e-05 1.11263430e-05*

*4.62209670e-04 1.41808522e-03 3.61164068e-03 9.21613430e-03*

*2.00959888e-02 3.71419143e-02 5.65755487e-02 7.15954534e-02*

*7.33300482e-02 6.03860169e-02 4.06991121e-02 2.44697403e-02*

*2.12248774e-02 3.18044332e-02 4.92258010e-02 6.13305197e-02*

*6.00212320e-02 4.50896631e-02 2.55011343e-02 9.26881783e-03*

*1.49917996e-03 -2.48867192e-04 -1.18621112e-04 -1.52340149e-05*

*-2.80694918e-06 -1.19040034e-05 -4.17131133e-05 1.17582919e-05*

*4.33047465e-04 1.36711585e-03 4.70303136e-03 1.32964370e-02*

*2.87130763e-02 4.84750107e-02 6.56580813e-02 7.15893644e-02*

*6.13933838e-02 3.74401897e-02 8.87313171e-03 -1.18076269e-02*

*-1.47541863e-02 6.08283955e-04 2.91158925e-02 5.62513996e-02*

*6.67667979e-02 5.59449175e-02 3.43614339e-02 1.29678491e-02*

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*-6.61090979e-06 -2.27954100e-05 -3.88714663e-05 3.85613906e-05*

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*4.07614129e-02 6.10774217e-02 7.16546701e-02 6.66513104e-02*

*4.70885759e-02 1.72506145e-02 -1.59555291e-02 -3.84411338e-02*

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*-8.25513663e-06 -1.57300776e-05 5.73695232e-06 1.67245795e-04*

*1.01090715e-03 4.58511248e-03 1.47728362e-02 3.33970877e-02*

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*-4.59363154e-06 -1.65707056e-05 4.10788920e-05 3.22353577e-04*

*1.75049504e-03 8.30343269e-03 2.34735818e-02 4.72522322e-02*

*7.09476685e-02 8.19525749e-02 7.40051474e-02 5.41795283e-02*

*2.91372123e-02 -4.84554135e-03 -4.21740569e-02 -6.00947891e-02*

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*7.82231321e-02 7.67080777e-02 5.68457875e-02 3.03058641e-02*

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*8.33574671e-02 7.95493714e-02 6.00886090e-02 3.41328718e-02*

*1.06348410e-02 3.82488154e-04 -6.87577136e-06 -6.54192047e-06*

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*3.57494587e-03 1.80547197e-02 4.35283201e-02 7.21405732e-02*

*8.83441294e-02 8.17055128e-02 5.90720432e-02 3.39428457e-02*

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*-2.06937124e-02 1.87208635e-02 5.85210647e-02 8.60963183e-02*

*9.44158808e-02 8.47472809e-02 6.15752966e-02 3.40783731e-02*

*1.14089297e-02 8.08681619e-04 -4.43300162e-05 -8.35242471e-06*

*-1.33590708e-07 4.59375088e-07 4.39896222e-05 6.67086392e-04*

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*0.00000000e+00 -2.23967127e-06 6.74216050e-05 1.04278557e-03*

*1.22051999e-02 4.07277824e-02 6.86549075e-02 8.89256125e-02*

*8.84056367e-02 6.57290924e-02 3.20828325e-02 -9.16908126e-04*

*-3.26477595e-02 -6.15232456e-02 -7.00949634e-02 -4.66254040e-02*

*-4.75337773e-03 4.12325083e-02 7.98863163e-02 1.00844381e-01*

*1.00015709e-01 7.83627743e-02 4.86830838e-02 2.22883593e-02*

*5.95052941e-03 3.60186109e-04 -1.00176978e-04 -1.05004222e-05*

*-3.36329009e-06 -3.03183521e-07 1.17162242e-04 1.73804516e-03*

*1.44600054e-02 4.20502884e-02 6.85729599e-02 8.71463179e-02*

*8.65126438e-02 6.48216184e-02 3.15656648e-02 -2.48368013e-03*

*-3.24296895e-02 -5.58931700e-02 -5.55452072e-02 -2.55150577e-02*

*2.04373489e-02 6.56747135e-02 9.70839466e-02 1.07707067e-01*

*9.47125448e-02 6.65551933e-02 3.75570004e-02 1.52444659e-02*

*3.51520135e-03 1.86252091e-04 -6.31088700e-05 -1.12293095e-05*

*-5.89585246e-07 -9.01927334e-06 1.64650385e-04 2.25086692e-03*

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*7.94114444e-02 5.03572781e-02 2.52805991e-02 9.11092305e-03*

*1.80573188e-03 6.31233720e-05 -4.32841260e-05 -6.07875738e-06*

*0.00000000e+00 -1.07751567e-06 1.94388620e-04 2.22862853e-03*

*1.28104810e-02 3.45840530e-02 6.03666062e-02 8.13079059e-02*

*8.87943210e-02 7.89654226e-02 5.51820074e-02 2.84567636e-02*

*6.73124386e-03 -2.62645754e-03 9.94972158e-03 4.10793446e-02*

*7.65408441e-02 9.88400583e-02 1.00085044e-01 8.24854435e-02*

*5.63750417e-02 3.16423090e-02 1.41029195e-02 4.71850734e-03*

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*-1.31166078e-06 4.01569161e-06 1.62164053e-04 1.72241771e-03*

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*7.95378025e-02 8.50557557e-02 7.36305940e-02 5.31242141e-02*

*3.20418299e-02 1.59161323e-02 6.53809143e-03 2.31919783e-03*

*5.04302817e-04 3.71527836e-05 6.32065679e-06 2.08047268e-06*

*-1.27067138e-06 -5.24066775e-07 7.45407861e-05 9.37170499e-04*

*4.24135199e-03 1.28826710e-02 2.75948716e-02 4.53466185e-02*

*5.93270030e-02 6.45845659e-02 5.98584726e-02 4.94275995e-02*

*4.04126883e-02 3.71659826e-02 4.07975039e-02 4.95313666e-02*

*5.51887008e-02 5.20641147e-02 4.03541198e-02 2.61390390e-02*

*1.40135594e-02 6.47147867e-03 2.75432525e-03 1.11767830e-03*

*3.06363522e-04 4.47678589e-05 6.39096984e-06 3.84087264e-06*

*0.00000000e+00 -1.89008408e-09 1.79982827e-05 2.55443359e-04*

*1.11779667e-03 3.55863608e-03 8.73058551e-03 1.65526901e-02*

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*2.24583055e-02 1.89548494e-02 1.75170337e-02 1.92930569e-02*

*2.14646207e-02 1.97036221e-02 1.44904161e-02 8.88072842e-03*

*4.84474767e-03 2.49784495e-03 1.12293419e-03 4.25568171e-04*

*1.08890114e-04 8.43742713e-06 -6.41064625e-06 0.00000000e+00*

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*7.32591930e-05 1.82559341e-04 3.46341901e-04 4.80290490e-04*

*3.29841159e-04 -9.86194684e-04 -3.46176363e-03 -5.43441193e-03*

*-6.68816058e-03 -6.92355919e-03 -5.69734383e-03 -2.54194311e-03*

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*1.69415724e-03 9.76244588e-04 4.81125731e-04 1.81905819e-04*

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*0.00000000e+00 0.00000000e+00 4.14741490e-07 -6.85617654e-06*

*-6.17352368e-05 -1.90911045e-04 -5.85549805e-04 -1.51165887e-03*

*-3.38630790e-03 -6.10527312e-03 -9.28946418e-03 -1.16109532e-02*

*-1.23833710e-02 -1.16137183e-02 -9.18256832e-03 -6.32306764e-03*

*-3.39067603e-03 -1.23830983e-03 -1.56424305e-05 4.85136747e-04*

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*-1.34802052e-03 -7.08181455e-04 -2.59297676e-04 4.85138183e-06*

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*-5.70818895e-05 -1.01220108e-04 -2.30080511e-04 -2.82364219e-04*

*-2.97966195e-04 -2.90659042e-04 -2.63320348e-04 -1.86028260e-04*

*-9.86302032e-05 -5.50416765e-05 -2.31407815e-05 3.28960092e-06*

*-5.74901597e-07 -6.03536876e-07 -7.83847550e-07 6.50876376e-08*

*0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00]*

*---------------------------------------------------------------------*

*Second Principal Component:*

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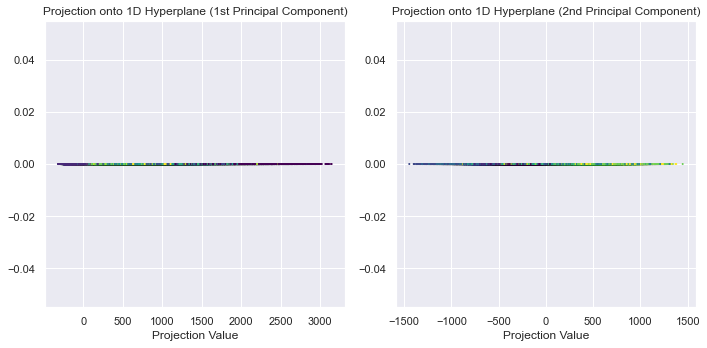
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*/--------------------------------------------------------------------*

*Explained Variance Ratio:*

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***Plot the projections of the first and second principal components onto a 1D hyperplane***

**

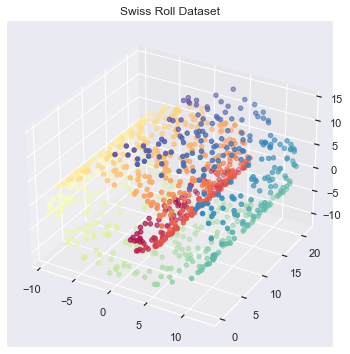
*Use Incremental PCA to reduce the dimensionality of the MNIST dataset down to 154 dimensions*

*Display the original and compressed digits from (5)*

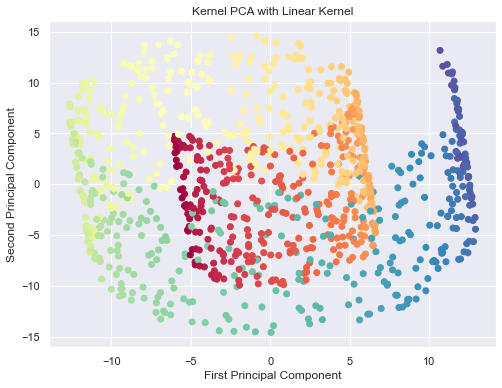
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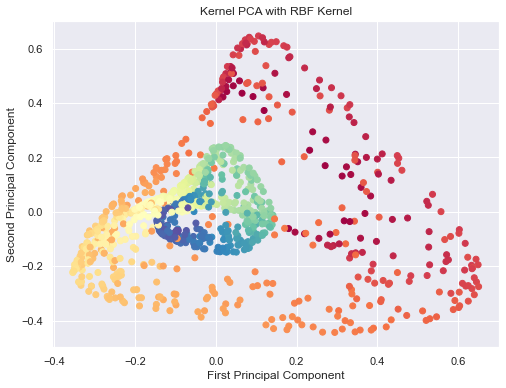
*Question 2*

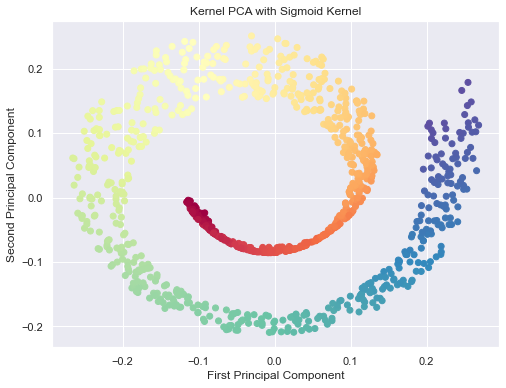
*Plot the resulting generated Swiss roll dataset.*

**

***Plot the kPCA results of applying the linear kernel (2 points), a RBF kernel (2 points), and a sigmoid kernel (2 points) from (3). Explain and compare the results***

**

**

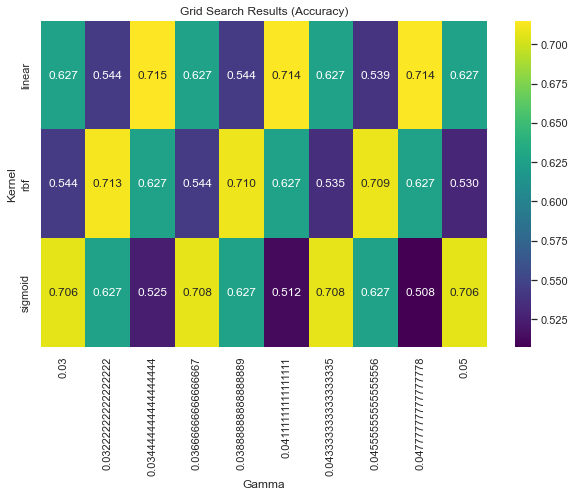
**

***Using kPCA and a kernel of your choice, apply Logistic Regression for classification. Use GridSearchCV to find the best kernel and gamma value for kPCA in order to get the best classification accuracy at the end of the pipeline. Print out best parameters found by GridSearchCV***

*Best Parameters: {'kpca\_\_gamma': 0.03, 'kpca\_\_kernel': 'sigmoid'}*

*Test Accuracy: 0.725*

***Plot the results from using GridSearchCV***

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