In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
```

In [2]:
```
# Importing the data set
dataset = pd.read_csv('DataB.csv', index_col = 0)
X = dataset.iloc[:,:-1].values
y = dataset.iloc[:,-1].values
```

In [3]:
```
dataset.head()
```

Out[3]:

	fea.1	fea.2	fea.3	fea.4	fea.5	fea.6	fea.7	fea.8	fea.9	fea.10	...	fea.776	fea.777	fea.778	fea.779	fea.780	fea.781	fea.782	fea.7
1	4	4	3	0	0	4	2	1	4	1	...	1	3	0	4	2	1	1	
2	5	1	4	3	1	3	5	1	4	4	...	1	1	3	3	1	3	3	
3	1	3	0	3	1	1	0	1	0	2	...	3	0	2	4	2	2	1	
4	5	3	2	3	5	2	2	0	4	5	...	5	4	5	1	4	4	2	
5	3	5	3	3	0	4	1	1	4	3	...	1	3	3	3	1	2	4	

5 rows × 785 columns

In [4]:
```
# Persorming scaling
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X = sc.fit_transform(X)
```

In [5]:
```
print(X)
```

```
[[ 1.01007711  0.96678184  0.35959365 ... -1.03428476  1.04733254
   1.64964331]
 [ 1.68717617 -1.02992387  1.02648816 ...  0.30710401  1.70203421
   0.98463588]
 [-1.02122007  0.30121327 -1.64108987 ... -1.03428476 -0.2620708
   0.98463588]
 ...
 [-0.34412101  0.30121327 -0.30730086 ... -1.03428476 -0.91677248
   0.31962845]
 [ 1.68717617 -0.3643553   1.02648816 ...  0.9777984   0.39263087
   0.98463588]
 [ 0.33297805  0.30121327 -0.97419536 ... -1.03428476  0.39263087
  -1.01038641]]
```

In [6]:
```
# Applying the PCA transformation
from sklearn.decomposition import PCA
pca = PCA()
XX = pca.fit_transform(X)
```

In [7]:
```
X2 = XX[:,:2]
X2.shape
```

Out[7]:
```
(2066, 2)
```

In [8]:
```
dataset[['gnd']]
```

Out[8]:

	gnd
1	0
2	0
3	0
4	0
5	0
...	...
2062	4
2063	4
2064	4
2065	4
2066	4

2066 rows × 1 columns

In [9]:
```
prin2 = pd.DataFrame(X2, columns=['pc1','pc2'], index = range(1,2067))
prin2_gnd = pd.concat([prin2,dataset[['gnd']]], axis = 1)
prin2_gnd
```

Out[9]:

	pc1	pc2	gnd
1	9.970692	-6.181722	0
2	11.416000	-6.941587	0
3	3.690119	-4.693097	0
4	7.312408	-6.042886	0
5	18.061520	-1.862436	0
...	...	...	...
2062	-1.917926	-0.397488	4
2063	0.525752	2.646714	4
2064	-0.349422	-0.933681	4
2065	-3.115263	-2.090474	4
2066	-5.644094	0.246167	4

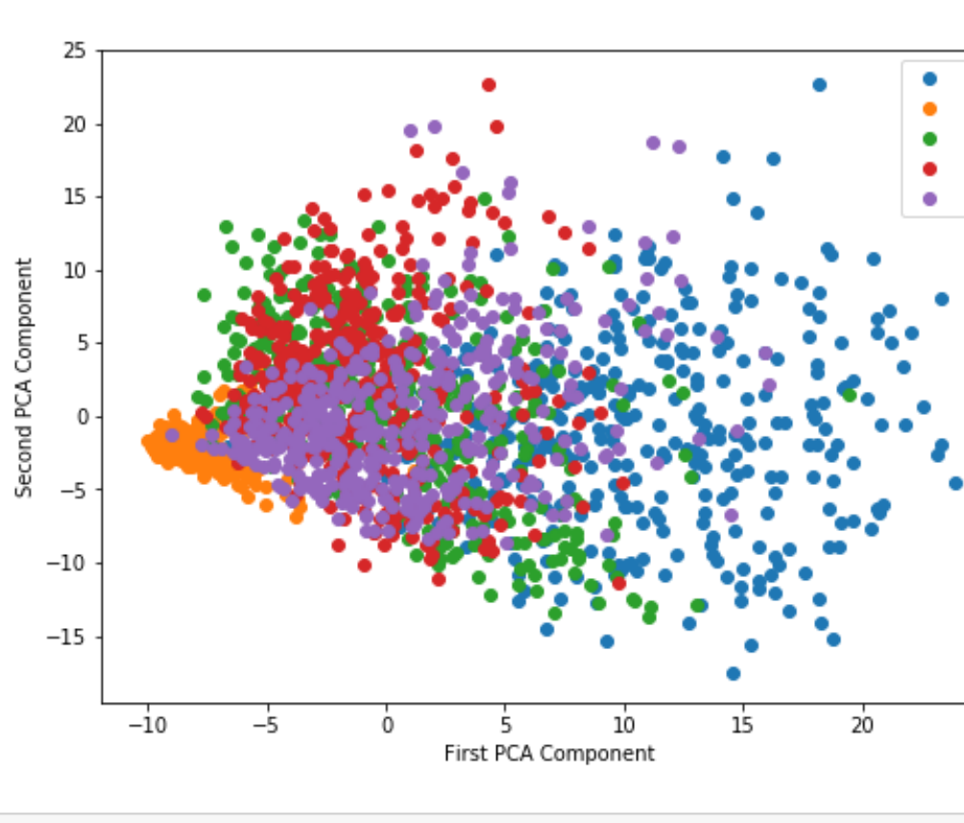
2066 rows × 3 columns

In [10]:
```
data0 = prin2_gnd[prin2_gnd['gnd']==0]
data1 = prin2_gnd[prin2_gnd['gnd']==1]
data2 = prin2_gnd[prin2_gnd['gnd']==2]
data3 = prin2_gnd[prin2_gnd['gnd']==3]
data4 = prin2_gnd[prin2_gnd['gnd']==4]
```

In [11]:
```
plt.figure(figsize=(8,6))

plt.scatter(data0['pc1'],data0['pc2'],label = 0)
plt.scatter(data1['pc1'],data1['pc2'],label = 1)
plt.scatter(data2['pc1'],data2['pc2'],label = 2)
plt.scatter(data3['pc1'],data3['pc2'],label = 3)
plt.scatter(data4['pc1'],data4['pc2'],label = 4)
plt.legend()
plt.xlabel('First PCA Component')
plt.ylabel('Second PCA Component')
```

Out[11]:
```
Text(0, 0.5, 'Second PCA Component')
```



In [12]:
```
X3 = XX[:,[5,6]]
X3.shape
```

Out[12]:
```
(2066, 2)
```

In [13]:
```
prin3 = pd.DataFrame(X3, columns=['pc5','pc6'], index = range(1,2067))
prin3_gnd = pd.concat([prin3,dataset[['gnd']]], axis = 1)
prin3_gnd
```

Out[13]:

	pc5	pc6	gnd
1	-2.844761	1.276232	0
2	-0.146431	1.683401	0
3	-3.226107	3.662990	0
4	-5.523882	3.971637	0
5	4.443076	-2.186078	0
...	...	...	...
2062	-2.309800	-3.861676	4
2063	4.547903	-1.437164	4
2064	-2.822867	-3.678327	4
2065	-2.586437	-2.099663	4
2066	-3.198489	2.975116	4

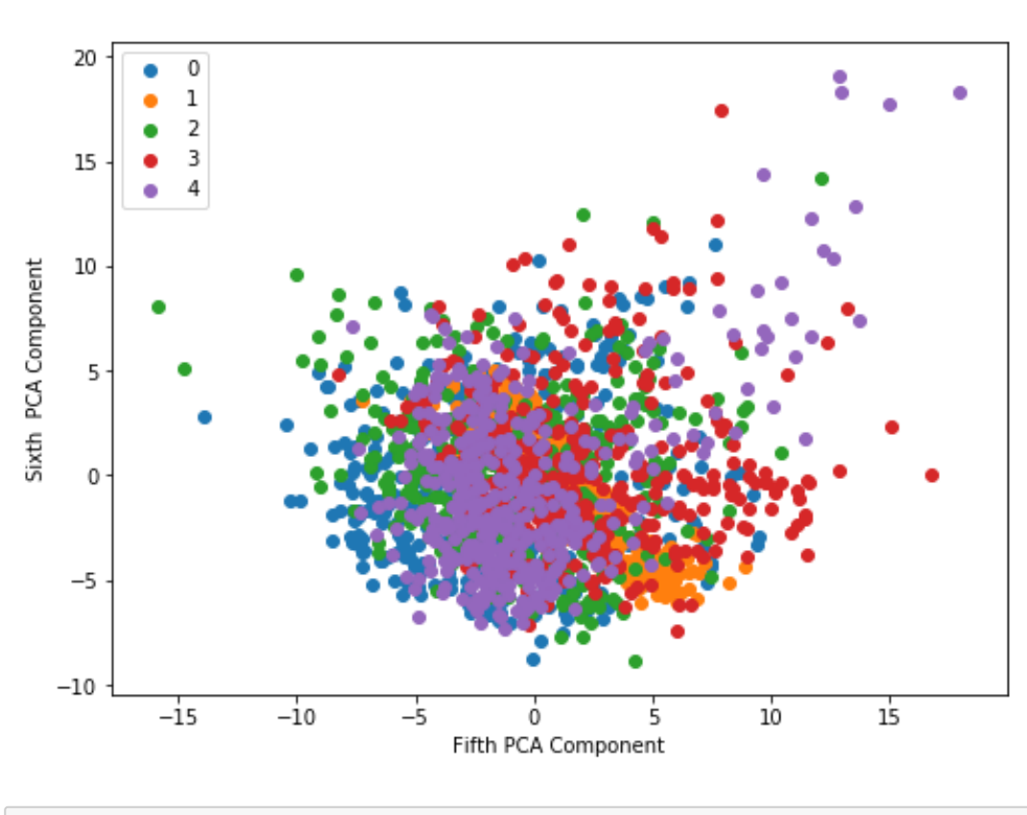
2066 rows × 3 columns

In [14]:
```
data5 = prin3_gnd[prin3_gnd['gnd']==0]
data6 = prin3_gnd[prin3_gnd['gnd']==1]
data7 = prin3_gnd[prin3_gnd['gnd']==2]
data8 = prin3_gnd[prin3_gnd['gnd']==3]
data9 = prin3_gnd[prin3_gnd['gnd']==4]
```

In [15]:
```
plt.figure(figsize = (8,6))

plt.scatter(data5['pc5'],data5['pc6'],label = 0)
plt.scatter(data6['pc5'],data6['pc6'],label = 1)
plt.scatter(data7['pc5'],data7['pc6'],label = 2)
plt.scatter(data8['pc5'],data8['pc6'],label = 3)
plt.scatter(data9['pc5'],data9['pc6'],label = 4)
plt.legend()
plt.xlabel('Fifth PCA Component')
plt.ylabel('Sixth  PCA Component')
```

Out[15]:
```
Text(0, 0.5, 'Sixth  PCA Component')
```



In [16]:
```
# To compute the eigenvalues and the eigenvectors
from numpy import linalg
covar = np.cov(XX.T)
w,v = linalg.eig(covar)
```

In [17]:
```
pca.explained_variance_
```

Out[17]:
```
array([5.17773194e+01, 2.88008646e+01, 2.67709105e+01, 2.39303462e+01,
       2.15750394e+01, 1.58935251e+01, 1.38619413e+01, 1.19120888e+01,
       1.06614183e+01, 9.82358285e+00, 9.11333621e+00, 8.28795842e+00,
       7.47022078e+00, 7.18685689e+00, 7.01821733e+00, 6.72923900e+00,
       6.17171361e+00, 6.03035494e+00, 5.97218819e+00, 5.74588510e+00,
       5.56641979e+00, 5.34085526e+00, 5.30999748e+00, 5.07244463e+00,
       4.90219996e+00, 4.74032764e+00, 4.46040954e+00, 4.43875834e+00,
       4.37522974e+00, 4.24991493e+00, 4.19736144e+00, 4.13191195e+00,
       4.00668370e+00, 3.89959838e+00, 3.82103747e+00, 3.75801773e+00,
       3.70087222e+00, 3.57242695e+00, 3.53870728e+00, 3.47609288e+00,
       3.37860197e+00, 3.27713810e+00, 3.19615121e+00, 3.18762080e+00,
       3.09982645e+00, 3.00645131e+00, 2.95668338e+00, 2.93613238e+00,
       2.84667418e+00, 2.80490440e+00, 2.77752432e+00, 2.73566237e+00,
       2.73062118e+00, 2.64033670e+00, 2.60241921e+00, 2.56556417e+00,
       2.48286895e+00, 2.46546582e+00, 2.43864084e+00, 2.41046503e+00,
       2.38602670e+00, 2.34433526e+00, 2.31096266e+00, 2.25866184e+00,
       2.23001715e+00, 2.19896413e+00, 2.15384123e+00, 2.14573490e+00,
       2.09323086e+00, 2.06319336e+00, 2.05255052e+00, 2.00585330e+00,
       1.96960581e+00, 1.95659528e+00, 1.92607287e+00, 1.90413259e+00,
       1.88067389e+00, 1.84329634e+00, 1.83261892e+00, 1.81640559e+00,
       1.80894894e+00, 1.80037769e+00, 1.79143455e+00, 1.77821823e+00,
       1.75344083e+00, 1.74420633e+00, 1.73235499e+00, 1.71703221e+00,
       1.69560958e+00, 1.67660264e+00, 1.67204995e+00, 1.66413703e+00,
       1.65298469e+00, 1.64607810e+00, 1.62658205e+00, 1.61023500e+00,
       1.59724824e+00, 1.59323756e+00, 1.58168294e+00, 1.56824196e+00,
       1.55793648e+00, 1.55649266e+00, 1.55126745e+00, 1.53478544e+00,
       1.52250847e+00, 1.51844179e+00, 1.50526693e+00, 1.50403086e+00,
       1.49832877e+00, 1.49084155e+00, 1.48107619e+00, 1.47692460e+00,
       1.47144049e+00, 1.46645002e+00, 1.44965194e+00, 1.44504737e+00,
       1.44001722e+00, 1.42705114e+00, 1.42253474e+00, 1.41615253e+00,
       1.40832241e+00, 1.40224124e+00, 1.39570127e+00, 1.38879684e+00,
       1.37904784e+00, 1.37790604e+00, 1.36580346e+00, 1.36372072e+00,
       1.35608476e+00, 1.34791805e+00, 1.33889606e+00, 1.33011761e+00,
       1.32803706e+00, 1.32266875e+00, 1.31925957e+00, 1.30663444e+00,
       1.30378173e+00, 1.29900900e+00, 1.29700677e+00, 1.29230361e+00,
       1.28317401e+00, 1.27869566e+00, 1.27308404e+00, 1.26556014e+00,
       1.25805205e+00, 1.25428149e+00, 1.25068531e+00, 1.24549638e+00,
       1.24082952e+00, 1.23076321e+00, 1.22902220e+00, 1.22246312e+00,
       1.21690294e+00, 1.21022711e+00, 1.20439342e+00, 1.19694226e+00,
       1.19615017e+00, 1.18957391e+00, 1.18452868e+00, 1.17925785e+00,
       1.17643009e+00, 1.16700758e+00, 1.16075509e+00, 1.15835675e+00,
       1.15396067e+00, 1.15189969e+00, 1.14384274e+00, 1.14069187e+00,
       1.13752338e+00, 1.13189592e+00, 1.13139929e+00, 1.12420692e+00,
       1.11827810e+00, 1.11548770e+00, 1.11099158e+00, 1.10138952e+00,
       1.09690924e+00, 1.08992340e+00, 1.08542061e+00, 1.08403100e+00,
       1.07573208e+00, 1.07238949e+00, 1.07044231e+00, 1.06348505e+00,
       1.05916097e+00, 1.05462755e+00, 1.05264302e+00, 1.04903755e+00,
       1.04551789e+00, 1.04244336e+00, 1.03551736e+00, 1.03059287e+00,
       1.02793382e+00, 1.02604314e+00, 1.02062715e+00, 1.01926849e+00,
       1.01399571e+00, 1.00607692e+00, 1.00034932e+00, 9.97241064e-01,
       9.96300176e-01, 9.92502857e-01, 9.89148104e-01, 9.87673495e-01,
       9.85365930e-01, 9.82087722e-01, 9.73538259e-01, 9.70484740e-01,
       9.68551405e-01, 9.62058947e-01, 9.59278503e-01, 9.54741785e-01,
       9.48903691e-01, 9.47150028e-01, 9.44766056e-01, 9.41552921e-01,
       9.36219160e-01, 9.33527611e-01, 9.27133401e-01, 9.19136858e-01,
       9.15317036e-01, 9.09679002e-01, 9.06488292e-01, 9.04317723e-01,
       9.00971593e-01, 8.95950438e-01, 8.93443276e-01, 8.87174910e-01,
       8.86152094e-01, 8.81600833e-01, 8.75550466e-01, 8.72929296e-01,
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       8.40107090e-01, 8.32021350e-01, 8.29797511e-01, 8.29226645e-01,
       8.24908728e-01, 8.22642837e-01, 8.19939354e-01, 8.16193388e-01,
       8.08486815e-01, 8.07311909e-01, 8.06320457e-01, 7.97794027e-01,
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       7.83650861e-01, 7.79302790e-01, 7.74021021e-01, 7.66836615e-01,
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       7.36367538e-01, 7.34130334e-01, 7.29754114e-01, 7.26669554e-01,
       7.25553750e-01, 7.21314970e-01, 7.14484346e-01, 7.14248107e-01,
       7.09604556e-01, 7.06770113e-01, 7.03714325e-01, 7.02451208e-01,
       6.97315619e-01, 6.91775224e-01, 6.90507958e-01, 6.87122515e-01,
       6.83204139e-01, 6.73332752e-01, 6.72064089e-01, 6.70835940e-01,
       6.67454324e-01, 6.65901511e-01, 6.63553634e-01, 6.59231255e-01,
       6.56485646e-01, 6.53754314e-01, 6.49661550e-01, 6.45516988e-01,
       6.41624530e-01, 6.39076267e-01, 6.34387727e-01, 6.31434905e-01,
       6.28142749e-01, 6.27861213e-01, 6.22403089e-01, 6.19960786e-01,
       6.15748915e-01, 6.11924976e-01, 6.07029625e-01, 6.06064272e-01,
       6.00039007e-01, 5.97293586e-01, 5.94933788e-01, 5.92335669e-01,
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       5.76114710e-01, 5.72776378e-01, 5.69479047e-01, 5.65553499e-01,
       5.60802097e-01, 5.59141210e-01, 5.55603060e-01, 5.54189268e-01,
       5.45885592e-01, 5.43739258e-01, 5.41730292e-01, 5.39352315e-01,
       5.30984709e-01, 5.30105949e-01, 5.26194708e-01, 5.22899231e-01,
       5.21120698e-01, 5.18188155e-01, 5.16202242e-01, 5.08474561e-01,
       5.05130550e-01, 5.01810375e-01, 4.95807021e-01, 4.93850110e-01,
       4.87083967e-01, 4.86569634e-01, 4.82167931e-01, 4.77047875e-01,
       4.74086648e-01, 4.68789346e-01, 4.67478001e-01, 4.61502325e-01,
       4.58685453e-01, 4.54396038e-01, 4.53461706e-01, 4.47196566e-01,
       4.46043328e-01, 4.43912263e-01, 4.39874259e-01, 4.36349443e-01,
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       4.15584708e-01, 4.12553489e-01, 4.10233937e-01, 4.08024749e-01,
       3.98674723e-01, 3.97115929e-01, 3.89934063e-01, 3.88639612e-01,
       3.84234632e-01, 3.80242671e-01, 3.78780838e-01, 3.76571612e-01,
       3.72641467e-01, 3.69165473e-01, 3.65162973e-01, 3.63140044e-01,
       3.58831277e-01, 3.56256261e-01, 3.54105607e-01, 3.49160525e-01,
       3.47193765e-01, 3.42656953e-01, 3.38724596e-01, 3.35606682e-01,
       3.34513248e-01, 3.28982477e-01, 3.26875218e-01, 3.22699371e-01,
       3.20094176e-01, 3.17876932e-01, 3.14163086e-01, 3.12300518e-01,
       3.09717107e-01, 3.05965486e-01, 3.00859731e-01, 2.98141683e-01,
       2.95031639e-01, 2.92417286e-01, 2.89846717e-01, 2.86487995e-01,
       2.85145365e-01, 2.81943014e-01, 2.78408600e-01, 2.76809791e-01,
       2.75513656e-01, 2.71395101e-01, 2.66976114e-01, 2.65251468e-01,
       2.61089787e-01, 2.59526033e-01, 2.55034747e-01, 2.50847577e-01,
       2.49689227e-01, 2.47829747e-01, 2.45961118e-01, 2.41359515e-01,
       2.40481006e-01, 2.38082649e-01, 2.35876613e-01, 2.33462181e-01,
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       2.25152106e-01, 2.21215068e-01, 2.18986055e-01, 2.16692457e-01,
       2.15475320e-01, 2.12699437e-01, 2.11357016e-01, 2.08931187e-01,
       2.07276926e-01, 2.06020823e-01, 2.03290460e-01, 1.99611330e-01,
       1.98471820e-01, 1.97866190e-01, 1.93837681e-01, 1.92976597e-01,
       1.91677989e-01, 1.88510208e-01, 1.87301759e-01, 1.85548154e-01,
       1.83485521e-01, 1.82091069e-01, 1.80960753e-01, 1.78632196e-01,
       1.77647580e-01, 1.75717987e-01, 1.72871118e-01, 1.72272677e-01,
       1.71331364e-01, 1.68551529e-01, 1.67383609e-01, 1.66087245e-01,
       1.64001010e-01, 1.62959572e-01, 1.62131713e-01, 1.61927475e-01,
       1.58793976e-01, 1.55533784e-01, 1.55076758e-01, 1.52683321e-01,
       1.50732422e-01, 1.50305380e-01, 1.47381014e-01, 1.46819402e-01,
       1.45150020e-01, 1.44400138e-01, 1.43501507e-01, 1.41900402e-01,
       1.40542945e-01, 1.39287007e-01, 1.38186242e-01, 1.35707083e-01,
       1.34994011e-01, 1.34682290e-01, 1.33618160e-01, 1.31516890e-01,
       1.31111114e-01, 1.29433115e-01, 1.29065504e-01, 1.28251175e-01,
       1.26604656e-01, 1.25771243e-01, 1.24769712e-01, 1.23637568e-01,
       1.21095969e-01, 1.19911967e-01, 1.19730852e-01, 1.19476591e-01,
       1.18624268e-01, 1.17474995e-01, 1.16128318e-01, 1.15569544e-01,
       1.14073460e-01, 1.13635090e-01, 1.12409932e-01, 1.10835269e-01,
       1.09296790e-01, 1.09012053e-01, 1.07522577e-01, 1.07379870e-01,
       1.06430100e-01, 1.05634697e-01, 1.04344425e-01, 1.03895819e-01,
       1.02716181e-01, 1.01918387e-01, 1.01261051e-01, 1.00016444e-01,
       9.95918258e-02, 9.86849711e-02, 9.72662314e-02, 9.59749195e-02,
       9.56962665e-02, 9.56204314e-02, 9.46941224e-02, 9.38321429e-02,
       9.26132724e-02, 9.23590703e-02, 9.16147812e-02, 9.06893041e-02,
       8.95027835e-02, 8.84370923e-02, 8.77201279e-02, 8.72902537e-02,
       8.70044651e-02, 8.64700757e-02, 8.59569739e-02, 8.40017086e-02,
       8.38315546e-02, 8.27684972e-02, 8.24120364e-02, 8.19015698e-02,
       8.13152113e-02, 8.02183390e-02, 7.99496365e-02, 7.90703097e-02,
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       7.30031184e-02, 7.30521527e-02, 7.10129231e-02, 7.14166133e-02,
       7.01675276e-02, 8.82056525e-03, 8.54048562e-03, 6.96339653e-02,
       6.91524368e-02, 6.78279910e-02, 6.86499091e-02, 6.84815711e-02,
       6.64154703e-02, 8.93192486e-03, 6.65768226e-02, 6.52307311e-02,
       6.54685573e-02, 6.49313582e-02, 9.09831448e-03, 9.31307758e-03,
       9.58849106e-03, 9.69892410e-03, 1.00322024e-02, 1.00736363e-02,
       1.01457638e-02, 1.06412158e-02, 1.08129008e-02, 1.09433143e-02,
       1.11619155e-02, 1.13628067e-02, 1.15190236e-02, 1.12373849e-02,
       1.16052660e-02, 6.40103113e-02, 6.35157398e-02, 6.29538177e-02,
       6.24854806e-02, 6.38173827e-02, 6.21808584e-02, 6.12706423e-02,
       6.10446346e-02, 5.97392837e-02, 5.91766347e-02, 6.07133938e-02,
       5.89186821e-02, 5.81079453e-02, 5.84101870e-02, 6.04153253e-02,
       5.77712617e-02, 5.68412903e-02, 5.76518061e-02, 5.60466599e-02,
       5.62265295e-02, 5.47622827e-02, 5.52925538e-02, 5.54994483e-02,
       5.40339091e-02, 5.42798615e-02, 5.35166013e-02, 5.33580911e-02,
       5.27466768e-02, 5.17381102e-02, 5.19094853e-02, 4.33645804e-02,
       4.37841578e-02, 4.40169979e-02, 4.45812991e-02, 4.47860905e-02,
       5.11206748e-02, 5.09995363e-02, 5.05584286e-02, 5.02855429e-02,
       4.51517821e-02, 4.66088195e-02, 4.67459736e-02, 4.62093948e-02,
       4.55270415e-02, 4.98603957e-02, 4.55698242e-02, 4.91383694e-02,
       4.77925592e-02, 4.82230419e-02, 4.79605073e-02, 4.87384503e-02,
       4.83905905e-02, 4.93420812e-02, 1.18335915e-02, 1.20787835e-02,
       1.22316057e-02, 1.24225729e-02, 1.27207821e-02, 1.26167660e-02,
       4.20642971e-02, 4.26163913e-02, 4.19048229e-02, 4.29655689e-02,
       4.17011860e-02, 4.28078357e-02, 1.29080794e-02, 1.28369117e-02,
       1.30555115e-02, 1.33046542e-02, 1.34022076e-02, 1.36723998e-02,
       1.35174614e-02, 1.39527048e-02, 1.41431281e-02, 1.42711101e-02,
       4.12948752e-02, 3.95369551e-02, 4.00258084e-02, 3.99198276e-02,
       3.85149257e-02, 4.06782667e-02, 4.05162084e-02, 3.60109143e-02,
       3.82158133e-02, 4.05862111e-02, 3.62540599e-02, 3.67223394e-02,
       3.72281748e-02, 3.77157303e-02, 3.79922830e-02, 3.75380764e-02,
       3.73445686e-02, 3.57157819e-02, 3.53589967e-02, 3.51586346e-02,
       3.46734865e-02, 3.58007915e-02, 3.43939298e-02, 3.42047572e-02,
       3.38517135e-02, 1.44948392e-02, 1.47397414e-02, 1.45343097e-02,
       3.35890936e-02, 1.48912318e-02, 3.32442373e-02, 3.36265712e-02,
       3.30842952e-02, 3.26197513e-02, 1.50939880e-02, 1.53408727e-02,
       3.18139552e-02, 3.14690733e-02, 1.54806987e-02, 3.11915807e-02,
       3.21068628e-02, 3.25170230e-02, 3.23264251e-02, 3.07603437e-02,
       1.97981614e-02, 1.57584247e-02, 1.60528103e-02, 1.59376580e-02,
       3.04923418e-02, 1.76953947e-02, 1.73777548e-02, 1.63564608e-02,
       1.66122410e-02, 1.67939333e-02, 1.67151921e-02, 1.94912911e-02,
       1.72645039e-02, 2.95315621e-02, 3.01982378e-02, 2.96749209e-02,
       1.56594762e-02, 1.78165760e-02, 1.63249513e-02, 1.71649898e-02,
       1.83372227e-02, 1.79698710e-02, 1.79045769e-02, 2.96221792e-02,
       2.90108159e-02, 1.85131345e-02, 1.84729470e-02, 2.88452743e-02,
       1.89298080e-02, 1.90708791e-02, 1.91693235e-02, 1.93290883e-02,
       2.85458236e-02, 2.02710347e-02, 2.06974275e-02, 2.01420891e-02,
       2.00692306e-02, 2.05913791e-02, 2.79547100e-02, 2.12710252e-02,
       2.11151985e-02, 2.20473726e-02, 2.41307523e-02, 2.56857193e-02,
       2.49695989e-02, 2.62203192e-02, 2.54467493e-02, 2.34748437e-02,
       2.39878391e-02, 2.38470137e-02, 2.28175385e-02, 2.46732490e-02,
       2.77680664e-02, 2.65527684e-02, 2.16714068e-02, 2.31125457e-02,
       2.53424289e-02, 2.47746319e-02, 2.82134229e-02, 2.24326849e-02,
       2.16129301e-02, 2.72990830e-02, 2.81321689e-02, 2.30548370e-02,
       2.68883330e-02, 2.75616741e-02, 1.88559855e-02, 2.74932374e-02,
       2.10086462e-02, 2.25853884e-02, 2.59201790e-02, 2.63324902e-02,
       2.36595171e-02, 2.69391617e-02, 2.25304264e-02, 3.06232530e-02])
```

In [19]:
```
# Eigenvectors
v
```

Out[19]:
```
array([[-1.00000000e+00,  2.87533438e-16, -2.64192235e-17, ...,
         6.64900413e-20, -2.28540047e-20, -1.79120566e-31],
       [-1.98604091e-16, -1.00000000e+00, -9.93084596e-16, ...,
         6.30762277e-19, -5.40511614e-19,  1.79398126e-18],
       [-1.93599161e-17, -7.80891474e-15,  1.00000000e+00, ...,
         2.15875708e-19,  7.35385099e-21, -1.99450797e-18],
       ...,
       [ 1.45392944e-19, -5.38633237e-19, -4.35004879e-18, ...,
         1.21888229e-16,  2.81075969e-16, -7.47462181e-17],
       [ 8.80661175e-19, -3.90060816e-18, -2.23383591e-17, ...,
         3.06609905e-16, -5.83921966e-17, -2.78264995e-17],
       [-1.74469487e-19,  8.71546992e-19,  3.90518089e-18, ...,
        -6.58856009e-17, -1.18036956e-16, -2.68606679e-17]])
```

In [20]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(XX, y, test_size = 0.25, random_state = 0)
```

In [21]:
```
print(y_test)
```

```
[3 1 4 0 4 0 4 0 0 2 0 4 4 2 2 3 4 4 4 3 4 1 3 4 1 2 2 4 4 1 3 1 0 2 2 0 1
 1 2 1 2 2 0 0 0 2 3 4 2 4 4 2 1 4 1 0 2 4 4 4 4 2 1 3 4 2 3 0 0 4 0 2 3 4
 0 3 1 0 1 1 2 3 4 1 4 1 4 2 1 0 1 2 1 2 1 0 3 0 2 3 0 4 1 2 1 0 3 2 2 3 1
 3 1 3 0 2 4 3 1 4 4 2 2 3 3 2 1 2 0 4 4 2 1 2 0 3 1 2 2 1 1 3 0 1 2 1 3 4
 2 4 1 3 0 1 4 1 0 4 4 0 2 0 2 2 0 3 0 2 2 0 3 1 2 3 1 4 4 3 4 3 2 0 1 1 0
 3 3 1 0 3 0 2 3 2 1 1 0 4 1 0 1 0 2 0 2 3 4 4 4 4 1 0 0 2 2 1 0 0 4 3 0 1
 2 1 4 1 0 1 2 1 3 3 4 1 2 3 3 4 1 3 2 4 1 4 4 2 3 1 4 1 1 0 3 0 3 4 1 3 2
 3 1 3 3 1 1 2 1 3 1 0 2 1 3 0 3 1 3 2 1 3 2 4 3 0 3 4 2 2 1 2 4 2 4 0 4 4
 2 2 1 1 1 4 1 4 3 0 2 2 0 0 4 4 2 0 4 0 1 3 2 1 3 2 3 4 2 3 1 4 1 3 1 1 0
 3 0 4 2 1 4 3 2 3 0 4 2 2 4 2 0 0 4 3 1 0 2 0 1 1 1 1 3 2 3 3 1 0 1 1 4 4
 4 0 2 4 1 4 0 2 2 3 2 0 3 1 0 0 2 3 4 1 3 1 0 0 4 1 3 3 2 4 1 4 0 2 1 2 1
 3 3 3 0 4 0 3 0 4 3 1 2 2 4 3 0 3 4 0 4 2 4 0 2 3 3 4 0 1 1 0 4 2 4 1 0 1
 3 3 3 0 3 2 0 4 3 4 3 4 3 0 2 0 0 3 1 3 3 2 3 3 0 0 2 3 1 1 0 4 1 2 1 3 0
 3 4 0 1 4 4 0 3 2 0 4 3 1 1 4 0 3 1 3 1 1 0 3 2 0 4 2 4 1 4 3 1 1 0 4 3]
```

In [22]:
```
from sklearn.naive_bayes import GaussianNB
classifier = GaussianNB()
classifier_e = GaussianNB()
classifier_f = GaussianNB()
classifier_g = GaussianNB()
classifier_p = GaussianNB()
classifier_t = GaussianNB()
classifier_h = GaussianNB()
classifier_u = GaussianNB()


classifier.fit(X_train[:,:2],y_train)
classifier_e.fit(X_train[:,:4],y_train)
classifier_f.fit(X_train[:,:10],y_train)
classifier_g.fit(X_train[:,:30],y_train)
classifier_p.fit(X_train[:,:60],y_train)
classifier_t.fit(X_train[:,:200],y_train)
classifier_h.fit(X_train[:,:500],y_train)
classifier_u.fit(X_train[:,:784],y_train)
```

Out[22]:
```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [23]:
```
y_pred_d = classifier.predict(X_test[:,:2])
y_pred_t = classifier_e.predict(X_test[:,:4])
y_pred_e = classifier_f.predict(X_test[:,:10])
y_pred_f = classifier_g.predict(X_test[:,:30])
y_pred_g = classifier_p.predict(X_test[:,:60])
y_pred_h = classifier_t.predict(X_test[:,:200])
y_pred_j = classifier_h.predict(X_test[:,:500])
y_pred_k = classifier_u.predict(X_test[:,:784])
```

In [24]:
```
from sklearn.metrics import accuracy_score
list = [y_pred_d, y_pred_t, y_pred_e, y_pred_f, y_pred_g, y_pred_h, y_pred_j, y_pred_k]
Acc = []
for i in list:
    Acc.append((1 - accuracy_score(y_test,i)))
```

In [25]:
```
Acc
```

Out[25]:
```
[0.4003868471953579,
 0.19342359767891681,
 0.07543520309477758,
 0.08704061895551263,
 0.19729206963249513,
 0.2707930367504836,
 0.30754352030947774,
 0.3036750483558994]
```

In [28]:
```
variance = pca.explained_variance_ratio_
```

In [29]:
```
variance.sum()
```

Out[29]:
```
0.9999999999999999
```

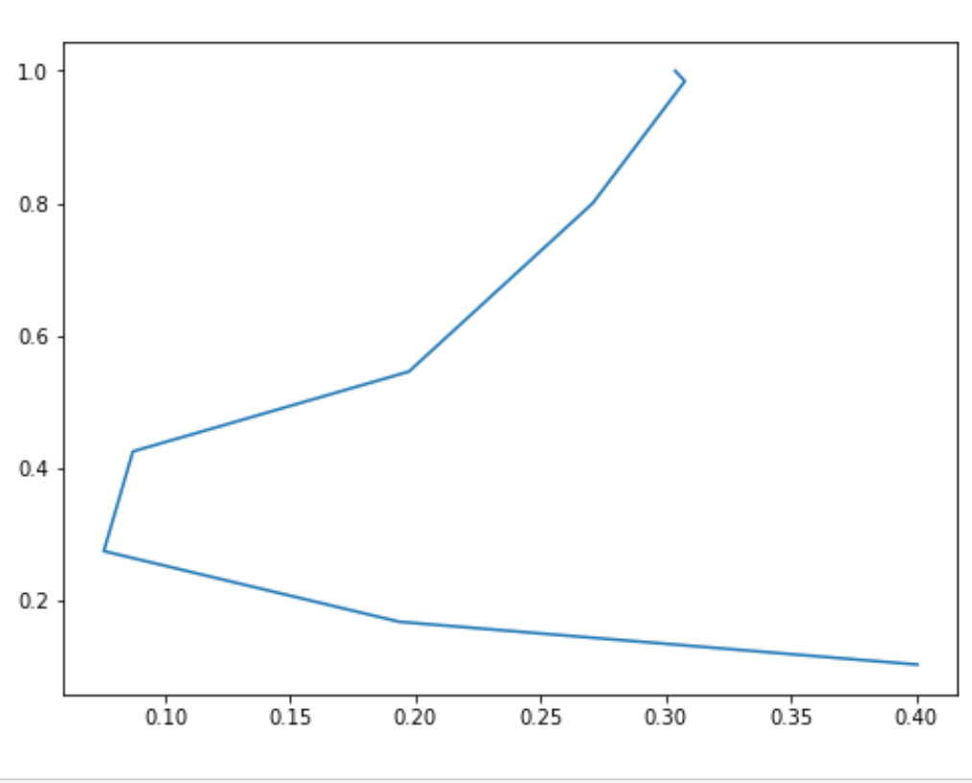
In [30]:
```
list = [2,4,10,30,60,200,500,784]
ret = []
for i in list:
    ret.append(variance[:i].sum())
```

In [31]:
```
ret
```

Out[31]:
```
[0.10272854850122914,
 0.16736721678023678,
 0.27411092759781536,
 0.42478098401772657,
 0.5454399805139987,
 0.8000317302015213,
 0.9843630768429739,
 0.9999999999999999]
```

In [32]:
```
plt.figure(figsize = (8,6))
plt.plot(Acc[:],ret[:])
```

Out[32]:
```
[<matplotlib.lines.Line2D at 0x7fccd872f8d0>]
```



In [33]:
```
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis as lda
LDA = lda(n_components = 2)
X_LDA = LDA.fit_transform(X,y)
```

In [34]:
```
X4 = X_LDA[:,:2]
X4.shape
```

Out[34]:
```
(2066, 2)
```

In [35]:
```
prin4 = pd.DataFrame(X4, columns = ['LDA0','LDA1'], index = range(1,2067))
prin4_gnd = pd.concat([prin4, dataset[['gnd']]], axis = 1)
prin4_gnd
```

Out[35]:

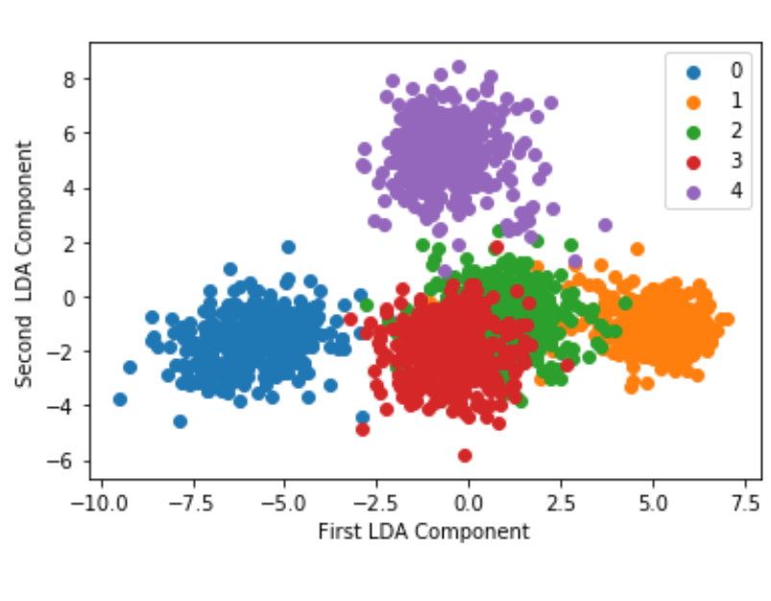
	LDA0	LDA1	gnd
1	-5.277233	-2.052912	0
2	-5.913727	-1.953482	0
3	-4.154543	-0.868888	0
4	-6.728769	-2.568941	0
5	-6.977105	-2.125944	0
...	...	...	...
2062	-1.493870	3.310943	4
2063	-0.249322	4.925294	4
2064	-1.311290	5.398086	4
2065	0.213247	5.160965	4
2066	0.404523	4.317396	4

2066 rows × 3 columns

In [36]:
```
data10 = prin4_gnd[prin4_gnd['gnd']==0]
data11 = prin4_gnd[prin4_gnd['gnd']==1]
data12 = prin4_gnd[prin4_gnd['gnd']==2]
data13 = prin4_gnd[prin4_gnd['gnd']==3]
data14 = prin4_gnd[prin4_gnd['gnd']==4]
```

In [37]:
```
plt.scatter(data10['LDA0'],data10['LDA1'], label = 0)
plt.scatter(data11['LDA0'],data11['LDA1'], label = 1)
plt.scatter(data12['LDA0'],data12['LDA1'], label = 2)
plt.scatter(data13['LDA0'],data13['LDA1'], label = 3)
plt.scatter(data14['LDA0'],data14['LDA1'], label = 4)
plt.legend()
plt.xlabel('First LDA Component')
plt.ylabel('Second  LDA Component')
```

Out[37]:
```
Text(0, 0.5, 'Second  LDA Component')
```



In [28]: X_pca

Out[28]: array([[-1.07723426, -1.25195126],
[1.12195195, -1.25195126],
[1.12195195, -1.25195126],
...,
[1.12195195, 1.25195126],
[1.12195195, 1.25195126],
[1.12195195, 1.25195126]])

In [29]: print(X_pca[:,0], X_pca[:,1])
plt.scatter(X_pca[:,0], X_pca[:,1], c=y, s=1)
plt.xlabel("First principal component")
plt.ylabel("Second principal component")

[-1.07723426 1.12195195 1.12195195 ... 1.12195195 1.12195195 1.12195195]
[-1.25195126 -1.25195126 -1.25195126 ... 1.25195126 1.25195126 1.25195126]

Out[29]: Text(0, 1.5), "Second 2D Component")

In [30]: X_train,X_test,y_train,y_test=train_test_split(X_pca,y,test_size=0.2,random_state=42)
from sklearn.metrics import accuracy_score
clf=DecisionTreeClassifier(criterion="gini",splitter="best",max_depth=None,min_samples_split=2,min_samples_leaf=1,min_weight_fraction_leaf=0.0,max_features=None,max_leaf_nodes=None,min_impurity_decrease=0.0,class_weight=None,ccp_alpha=0.0)
clf.fit(X_train,y_train)
y_pred=clf.predict(X_test)
print("Accuracy",accuracy_score(y_test,y_pred))

In [31]: y_pred.shape

Out[31]: (2000,)

In [32]: cm=confusion_matrix(y_test,y_pred)
print(cm)
sns.heatmap(cm,annot=True,fmt="d",cmap="Blues")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.title("Confusion Matrix")

Out[32]: 0.20