Scientific Computing 2
HomeWork 4

Question 1:

```
[X , Y] = eig(C)
```

```
X = 12×12
Y = 12×12     Rows 2:11 | Columns 1:12
```

```
U1 = Xcentered*X(:,1)/sqrt(Y(1,1))
```

```
U1 = 50×1
```

```
U2 = Xcentered*X(:,2)/sqrt(Y(2,2))
```

```
U2 = 50×1
```

```
U3 = Xcentered*X(:,3)/sqrt(Y(3,3))
```

```
U3 = 50×1
```

```
U4 = Xcentered*X(:,4)/sqrt(Y(4,4))
```

```
U4 = 50×1
```

```
U5 = Xcentered*X(:,5)/sqrt(Y(5,5))
```

```
U5 = 50×1
```

```
U6 = Xcentered*X(:,6)/sqrt(Y(6,6))
```

```
U6 = 50×1
```

```
U7 = Xcentered*X(:,7)/sqrt(Y(7,7))
```

```
U7 = 50×1
```

```
U8 = Xcentered*X(:,8)/sqrt(Y(8,8))
```

```
U8 = 50×1
```

```
U9 = Xcentered*X(:,9)/sqrt(Y(9,9))
```

```
U9 = 50×1
```

```
U10 = Xcentered*X(:,10)/sqrt(Y(10,10))
```

```
U10 = 50×1
```

```
U11= Xcentered*X(:,11)/sqrt(Y(11,11))
```

```
U11 = 50×1
```

```
U12 = Xcentered*X(:,12)/sqrt(Y(12,12))
```

```
U12 = 50×1
```

```
U = [U1 U2 U3 U4 U5 U6 U7 U8 U9 U10 U11 U12]
```

```
U = 50×12
   -1.3982    0.8883    0.1154    0.3522    0.8211    0.1351   -1.9167   -1.3319   -1.6779    0.7509
1.6878   -0.2651
    0.0804    0.5730   -0.9486    1.4770    0.3205   -0.8920   -0.6602    0.0755   -0.3535   -0.5198
0.4233   -1.3365
    0.2531   -0.3623   -0.2197   -1.0332   -0.4879   -0.3966   -0.2203   -0.5000   -0.1675   -0.6244
2.0435    0.1179
    1.3205   -0.5447    0.4315    0.7049    1.3084    1.3801   -0.3524   -0.5007    0.6354   -1.1237   -
0.8978   -0.0251
    0.5861   -0.6785    0.1751   -0.1396    0.2085    0.7763   -0.9123   -0.7977   -0.0951    0.4722
0.9630   -0.1305
   -0.9164    1.4044    1.4966    0.2060    0.2248   -0.4469   -0.3135    1.0031    1.2046    1.0608
0.7002    1.6149
    1.1435    0.5852    0.9694   -0.1842    1.1124   -0.3077   -1.1883    0.4258    0.2186   -0.1607   -
0.0618   -2.6135
   -0.3664    0.1020   -0.5964    0.1338    0.4571   -1.2171   -0.8032    0.1117    1.1040   -0.5835   -
1.5392    1.6494
```

```
   -0.4617    0.6556    0.0998    0.2380   -0.4529   -0.7793   -0.8961   -1.0772    1.0205   -1.6301
1.1646   -0.2542
    0.0617   -1.8046    0.4487    0.4687    0.5949    1.1144   -0.5624    1.4623   -1.6564   -0.6433   -
0.4973    1.3428
```

```
%Principal Component 1 is the eigen vector with highest eigen value
P = sqrt(Y(12,12))*U12*X(:,12)'
```

```
P = 50×12
   -0.0217   -0.0057   -0.0088   -0.0028    0.0517    0.0384    0.0462    0.0204   -0.1551   -0.0455   -
0.1302   -0.0254
   -0.1095   -0.0287   -0.0445   -0.0143    0.2609    0.1935    0.2328    0.1030   -0.7821   -0.2292   -
0.6567   -0.1282
    0.0097    0.0025    0.0039    0.0013   -0.0230   -0.0171   -0.0205   -0.0091    0.0690    0.0202
0.0579    0.0113
   -0.0021   -0.0005   -0.0008   -0.0003    0.0049    0.0036    0.0044    0.0019   -0.0147   -0.0043   -
0.0123   -0.0024
   -0.0107   -0.0028   -0.0043   -0.0014    0.0255    0.0189    0.0227    0.0101   -0.0764   -0.0224   -
0.0641   -0.0125
    0.1324    0.0346    0.0537    0.0173   -0.3153   -0.2338   -0.2813   -0.1245    0.9450    0.2769
0.7935    0.1549
   -0.2142   -0.0561   -0.0870   -0.0280    0.5102    0.3784    0.4552    0.2014   -1.5294   -0.4481   -
1.2842   -0.2506
    0.1352    0.0354    0.0549    0.0177   -0.3220   -0.2388   -0.2873   -0.1271    0.9652    0.2828
0.8104    0.1582
   -0.0208   -0.0055   -0.0085   -0.0027    0.0496    0.0368    0.0443    0.0196   -0.1487   -0.0436   -
0.1249   -0.0244
    0.1101    0.0288    0.0447    0.0144   -0.2621   -0.1944   -0.2339   -0.1035    0.7858    0.2303
0.6598    0.1288
```

```
%frobenius norm of the matrices
no = norm(Xcentered - P,'fro')
```

```
no = 7.2853
```

```
%Principal Component 2 has 2 eigen values with highest eigen values
P1 = sqrt(Y(12,12))*U12*X(:,12)'
```

```
P1 = 50×12
```

```
P2 = sqrt(Y(11,11))*U11*X(:,11)'
```

```
P2 = 50×12
```

```
P = P1 + P2
```

```
P = 50×12
   -0.0472   -0.0853   -0.0470   -0.0137    0.7805    0.3117    0.7128    0.2326    0.1391   -0.0245
0.1500    0.0371
   -0.1159   -0.0486   -0.0541   -0.0170    0.4437    0.2620    0.4000    0.1562   -0.7083   -0.2239   -
0.5864   -0.1125
   -0.0212   -0.0938   -0.0423   -0.0119    0.8593    0.3139    0.7866    0.2478    0.4252    0.0456
0.3973    0.0870
    0.0115    0.0418    0.0195    0.0055   -0.3827   -0.1417   -0.3502   -0.1109   -0.1712   -0.0155   -
0.1614   -0.0357
   -0.0252   -0.0482   -0.0261   -0.0076    0.4412    0.1748    0.4031    0.1311    0.0915   -0.0104
0.0958    0.0231
    0.1218    0.0016    0.0379    0.0128   -0.0129   -0.1204   -0.0047   -0.0364    1.0671    0.2856
0.9098    0.1808
   -0.2133   -0.0531   -0.0856   -0.0276    0.4835    0.3683    0.4308    0.1936   -1.5402   -0.4489   -
1.2944   -0.2529
    0.1584    0.1079    0.0897    0.0276   -0.9866   -0.4880   -0.8952   -0.3206    0.6969    0.2637
0.5549    0.1012
   -0.0384   -0.0604   -0.0348   -0.0102    0.5525    0.2254    0.5043    0.1660    0.0543   -0.0291
0.0685    0.0188
    0.1176    0.0522    0.0559    0.0176   -0.4769   -0.2749   -0.4303   -0.1660    0.6991    0.2241
0.5772    0.1104
```

```
%frobenius norm of the matrices
no1 = norm(Xcentered- P, 'fro')
```
```
no1 = 5.5433
```
```
%Principal Component 3 has 3 eigen vectors with highest eigen values
P1 = sqrt(Y(12,12))*U12*X(:,12)'
```
```
P1 = 50×12
```
```
P2 = sqrt(Y(11,11))*U11*X(:,11)'
```
```
P2 = 50×12
```
```
P3 = sqrt(Y(10,10))*U10*X(:,10)'
```
```
P3 = 50×12
```
```
P = P1+P2+P3
```
```
P = 50×12
    0.1883    0.1765   -0.0201    0.0097    0.8052    0.3223    0.7276    0.2598    0.0901    0.0056
0.1565    0.0924
   -0.2790   -0.2298   -0.0727   -0.0333    0.4265    0.2547    0.3897    0.1374   -0.6744   -0.2447   -
0.5909   -0.1508
   -0.2171   -0.3115   -0.0647   -0.0315    0.8387    0.3050    0.7742    0.2252    0.4660    0.0206
0.3918    0.0410
   -0.3410   -0.3500   -0.0208   -0.0296   -0.4198   -0.1577   -0.3724   -0.1517   -0.0979   -0.0605   -
0.1711   -0.1185
    0.1229    0.1164   -0.0092    0.0071    0.4568    0.1815    0.4124    0.1482    0.0607    0.0085
0.0999    0.0580
    0.4545    0.3715    0.0759    0.0459    0.0220   -0.1054    0.0163    0.0020    0.9979    0.3281
0.9190    0.2590
   -0.2637   -0.1092   -0.0913   -0.0326    0.4782    0.3661    0.4276    0.1878   -1.5297   -0.4554   -
1.2958   -0.2648
   -0.0246   -0.0955    0.0688    0.0094   -1.0058   -0.4963   -0.9067   -0.3418    0.7349    0.2403
0.5498    0.0582
   -0.5498   -0.6287   -0.0932   -0.0612    0.4987    0.2023    0.4720    0.1069    0.1607   -0.0944
0.0544   -0.1014
   -0.0842   -0.1720    0.0329   -0.0025   -0.4981   -0.2841   -0.4430   -0.1893    0.7411    0.1983
0.5716    0.0629
```
```
%frobenius norm of the matrices
no2 = norm(Xcentered- P, 'fro')
```
```
no2 = 4.3473
```
```
%Principal Component 4 has 4 eigen vectors with highest eigen values
P1 = sqrt(Y(12,12))*U12*X(:,12)'
```
```
P1 = 50×12
```
```
P2 = sqrt(Y(11,11))*U11*X(:,11)'
```
```
P2 = 50×12
```
```
P3 = sqrt(Y(10,10))*U10*X(:,10)'
```
```
P3 = 50×12
```
```
P4 = sqrt(Y(9,9))*U9*X(:,9)'
```
```
P4 = 50×12
```
```
P = P1+P2+P3+ P4
```
```
P = 50×12
    0.2081    0.0382   -0.0298    0.0165    0.8815    0.4785    0.5950    0.2416    0.0336    0.3921
0.0593    0.3965
   -0.2748   -0.2590   -0.0747   -0.0319    0.4426    0.2876    0.3617    0.1335   -0.6863   -0.1633   -
0.6114   -0.0868
   -0.2151   -0.3253   -0.0657   -0.0308    0.8463    0.3206    0.7610    0.2234    0.4603    0.0592
0.3821    0.0713
   -0.3485   -0.2976   -0.0171   -0.0322   -0.4487   -0.2168   -0.3222   -0.1448   -0.0765   -0.2068   -
0.1343   -0.2336
    0.1240    0.1086   -0.0098    0.0075    0.4611    0.1904    0.4049    0.1472    0.0575    0.0304
0.0944    0.0752
```

```
    0.4403    0.4708    0.0828    0.0411   -0.0327   -0.2175    0.1115    0.0151    1.0385    0.0507
0.9888    0.0407
   -0.2662   -0.0911   -0.0901   -0.0335    0.4683    0.3457    0.4449    0.1902   -1.5223   -0.5057   -
1.2832   -0.3044
   -0.0376   -0.0044    0.0752    0.0049   -1.0560   -0.5991   -0.8194   -0.3298    0.7721   -0.0140
0.6138   -0.1419
   -0.5618   -0.5445   -0.0874   -0.0653    0.4523    0.1073    0.5527    0.1180    0.1950   -0.3294
0.1135   -0.2863
   -0.0647   -0.3087    0.0234    0.0041   -0.4228   -0.1299   -0.5740   -0.2073    0.6852    0.5798
0.4757    0.3631
```

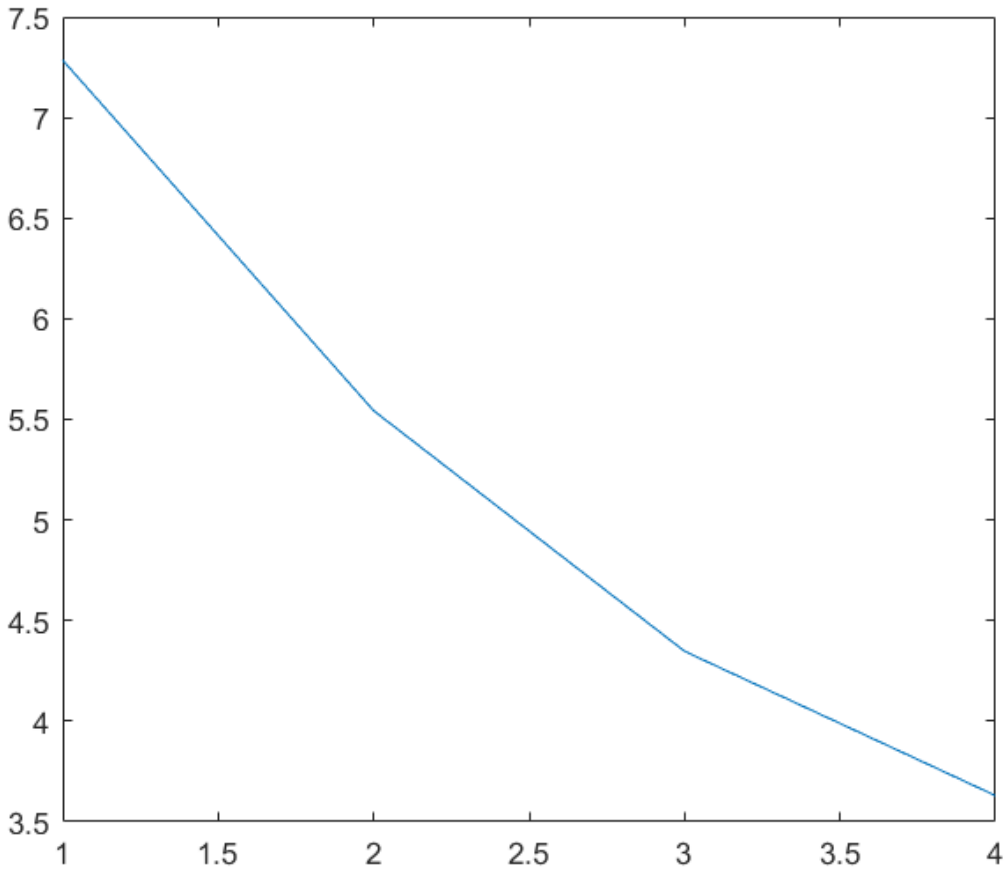
```
%frobenius norm of the matrices
no3 = norm(Xcentered- P, 'fro')
```

```
no3 = 3.6299
```

```
frobenius = [no no1 no2 no3]
```

```
frobenius = 1×4
    7.2853    5.5433    4.3473    3.6299
```

```
plot(frobenius)
```




```
 [X , Y] = eig(S)
```

```
X = 12×12

Y = 12×12
```

```
U1 = Second*X(:,1)/sqrt(Y(1,1))
```

```
U1 = 50×1
```

```
U2 = Second*X(:,2)/sqrt(Y(2,2))
```

```
U2 = 50×1
```

```
U3 = Second*X(:,3)/sqrt(Y(3,3))
```

```
U3 = 50×1
```

```
U4 = Second*X(:,4)/sqrt(Y(4,4))
```

```
U4 = 50×1
```

```
U5 = Second*X(:,5)/sqrt(Y(5,5))
```
```
U5 = 50×1
```

```
U6 = Second*X(:,6)/sqrt(Y(6,6))
```
```
U6 = 50×1
```

```
U7 = Second*X(:,7)/sqrt(Y(7,7))
```
```
U7 = 50×1
```

```
U8 = Second*X(:,8)/sqrt(Y(8,8))
```
```
U8 = 50×1
```

```
U9 = Second*X(:,9)/sqrt(Y(9,9))
```
```
U9 = 50×1
```

```
U10 = Second*X(:,10)/sqrt(Y(10,10))
```
```
U10 = 50×1
```

```
U11= Second*X(:,11)/sqrt(Y(11,11))
U12 = Second*X(:,12)/sqrt(Y(12,12))
U = [U1 U2 U3 U4 U5 U6 U7 U8 U9 U10 U11 U12]
```
```
U =
    0.9636    0.9135   -0.0437    0.2724   -0.8056    0.1434   -2.3138   -1.3666   -1.3009    0.3432
0.9607    1.0656
   -0.0407    0.5729    1.0183    1.4052   -0.2935   -1.1637   -0.3538    0.0799   -0.4597    0.3928
1.3664    0.9690
   -0.5160   -0.3356    0.2369   -1.1258    0.5535   -0.0410   -0.4261   -0.5115   -0.0081    1.7224
0.6161    1.0654
   -0.7474   -0.5852   -0.5244    0.9113   -1.4553    0.6296   -0.1249   -0.4890    0.3715    0.3595   -
0.4120    0.9438
   -0.6650   -0.6664   -0.1818   -0.1169   -0.2452    0.7465   -1.2192   -0.8162    0.1235    0.2031
0.5247    1.0349
    0.4331    1.4431   -1.3996    0.1287   -0.1685   -0.1509   -0.5273    0.9907    1.4928   -0.1013   -
1.1349    1.0855
   -0.7810    0.5663   -1.0195   -0.0913   -1.1375   -0.9462   -0.7933    0.4322    0.0562   -0.3607
2.3820    0.9176
    0.5630    0.0802    0.5846    0.1146   -0.4194   -1.6931   -0.2303    0.1271    0.8750   -0.1771   -
2.1442    0.9800
    0.5501    0.6430   -0.1042    0.2549    0.4697   -1.1274   -0.5256   -1.0699    0.8767    1.9478
0.5340    1.0044
    0.0332   -1.8159   -0.4799    0.5717   -0.6821    0.8478   -0.7398    1.4525   -1.6837    0.3797   -
1.4601    1.0110
```
```
%Principal Component 1 is the eigen vector with highest eigen value
P = sqrt(Y(12,12))*U12*X(:,12)'
```
```
P =
    5.3357    3.6426    1.5592    0.2604    6.3293    2.9507    4.5440    1.4143    7.0355    3.1725
5.9305    2.1622
    4.8517    3.3122    1.4178    0.2368    5.7552    2.6830    4.1318    1.2860    6.3973    2.8847
5.3925    1.9661
    5.3347    3.6419    1.5589    0.2603    6.3281    2.9501    4.5431    1.4141    7.0342    3.1718
5.9294    2.1618
    4.7255    3.2260    1.3809    0.2306    5.6055    2.6132    4.0243    1.2526    6.2309    2.8096
5.2523    1.9150
    5.1817    3.5375    1.5142    0.2529    6.1467    2.8655    4.4129    1.3735    6.8325    3.0809
5.7594    2.0998
    5.4351    3.7105    1.5883    0.2652    6.4472    3.0057    4.6287    1.4407    7.1666    3.2316
6.0410    2.2025
```

```
    4.5946    3.1367    1.3426    0.2242    5.4502    2.5408    3.9128    1.2179    6.0583    2.7318
5.1068    1.8619
    4.9068    3.3498    1.4339    0.2394    5.8205    2.7135    4.1787    1.3006    6.4699    2.9174
5.4538    1.9884
    5.0292    3.4333    1.4696    0.2454    5.9657    2.7811    4.2829    1.3331    6.6313    2.9902
5.5898    2.0380
    5.0623    3.4560    1.4793    0.2470    6.0050    2.7995    4.3111    1.3419    6.6750    3.0099
5.6266    2.0514
```

```
%frobenius norm of the matrices
no = norm(Second - P,'fro')
```

```
no = 8.1775
```

```
%Principal Component 2 has 2 eigen values with highest eigen values
P1 = sqrt(Y(12,12))*U12*X(:,12)'
P2 = sqrt(Y(11,11))*U11*X(:,11)'
P = P1 + P2
```

```
P =
    5.3399    3.6725    1.5415    0.2540    6.7276    3.1709    4.8889    1.5455    6.6480    3.0638
5.6163    2.1202
    4.8576    3.3547    1.3926    0.2277    6.3217    2.9962    4.6224    1.4726    5.8462    2.7301
4.9456    1.9062
    5.3373    3.6611    1.5476    0.2563    6.5835    3.0913    4.7643    1.4982    6.7857    3.1022
5.7279    2.1348
    4.7237    3.2132    1.3885    0.2333    5.4346    2.5188    3.8764    1.1963    6.3971    2.8563
5.3870    1.9330
    5.1840    3.5538    1.5046    0.2494    6.3642    2.9858    4.6013    1.4452    6.6208    3.0216
5.5878    2.0769
    5.4302    3.6752    1.6091    0.2727    5.9767    2.7455    4.2212    1.2857    7.6244    3.3600
6.4122    2.2523
    4.6049    3.2107    1.2988    0.2085    6.4378    3.0868    4.7681    1.5431    5.0975    2.4623
4.3277    1.7575
    4.8975    3.2831    1.4733    0.2536    4.9314    2.2220    3.4088    1.0079    7.3348    3.1600
6.1551    2.0824
    5.0315    3.4499    1.4598    0.2419    6.1871    2.9036    4.4747    1.4060    6.4159    2.9298
5.4151    2.0146
    5.0560    3.4106    1.5062    0.2567    5.3996    2.4648    3.7869    1.1425    7.2640    3.1751
6.1042    2.1154
```

```
%frobenius norm of the matrices
no1 = norm(Second- P, 'fro')
```

```
no1 = 5.8295
```

```
%Principal Component 3 has 3 eigen vectors with highest eigen values
P1 = sqrt(Y(12,12))*U12*X(:,12)'

P2 = sqrt(Y(11,11))*U11*X(:,11)'
P3 = sqrt(Y(10,10))*U10*X(:,10)'
P = P1+P2+P3
%frobenius norm of the matrices
no2 = norm(Second- P, 'fro')
```

```
no2 = 4.4052
```

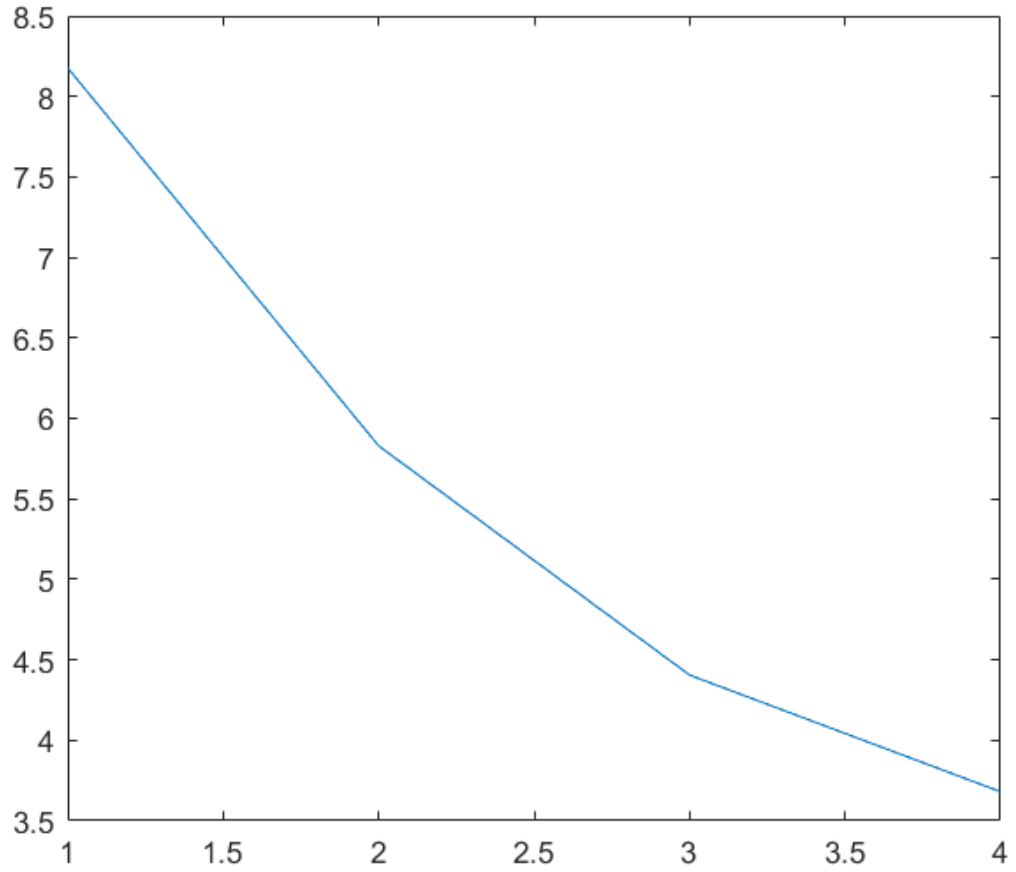
```
%Principal Component 4 has 4 eigen vectors with highest eigen values
P1 = sqrt(Y(12,12))*U12*X(:,12)'
P2 = sqrt(Y(11,11))*U11*X(:,11)'
P3 = sqrt(Y(10,10))*U10*X(:,10)'
P4 = sqrt(Y(9,9))*U9*X(:,9)'
P = P1+P2+P3+ P4
%frobenius norm of the matrices
no3 = norm(Second- P, 'fro')
```

```
no3 = 3.6805
```

```
frobenius = [no no1 no2 no3]
```

```
frobenius =
```

```
    8.1775    5.8295    4.4052    3.6805
plot(frobenius)
```




```
 [X , Y] = eig(S)
U1 = Xnorm*X(:,1)/sqrt(Y(1,1))
U2 = Xnorm*X(:,2)/sqrt(Y(2,2))
U3 = Xnorm*X(:,3)/sqrt(Y(3,3))
U4 = Xnorm*X(:,4)/sqrt(Y(4,4))
U5 = Xnorm*X(:,5)/sqrt(Y(5,5))
U6 = Xnorm*X(:,6)/sqrt(Y(6,6))
U7 = Xnorm*X(:,7)/sqrt(Y(7,7))
U8 = Xnorm*X(:,8)/sqrt(Y(8,8))
U9 = Xnorm*X(:,9)/sqrt(Y(9,9))
U10 = Xnorm*X(:,10)/sqrt(Y(10,10))
U11= Xnorm*X(:,11)/sqrt(Y(11,11))
U12 = Xnorm*X(:,12)/sqrt(Y(12,12))
U = [U1 U2 U3 U4 U5 U6 U7 U8 U9 U10 U11 U12]
U =
    3.9118   -1.0776    0.4952   -0.2847   -0.0172    0.8890   -6.3153   -0.9635   -4.6497    0.5490
1.9773    0.1584
   -1.8860   -2.7286    4.4159    2.7161   -0.1084   -4.3074   -1.2089    2.1094   -0.4144    1.6621
2.8100   -0.0508
   -3.1026   -4.1393    3.0819   -3.8077    0.8309    0.0429   -2.9258    0.6695   -0.6079    3.9568
1.6285    0.1204
    0.3333   -4.1764   -1.2119    2.0293   -3.7962    2.0520    0.9237   -2.3436    1.6639    1.4430   -
1.1036   -0.1319
   -3.4129   -6.2407    0.7992   -0.5391    0.1490    2.4903   -3.6532   -0.6669    0.0039    0.3787
1.1419    0.0794
   -6.0978   10.1263   -8.5791    3.0236   -0.3017   -0.8448    0.2370    1.6141    2.7762   -1.4946   -
1.9409    0.1778
  -12.7886   -0.1393   -1.5155   -2.1067   -1.3179   -5.0433   -1.6299    3.3766    1.8711    0.4436
```

```
4.7346   -0.1403
   11.8423    2.6071    1.3910   -0.0568   -1.7527   -3.3098    0.8610   -2.3038    2.3258   -0.5666   -
4.4037   -0.0715
    4.2371    0.1552    0.8913   -0.3227    1.2141   -3.6367   -1.5116   -1.8552    2.8381    5.0278
1.2379   -0.0242
    7.1469  -12.6184   -0.8518    2.5879   -2.1273    3.9455   -2.8280    2.8024   -6.0503    0.7762   -
2.8835    0.0260
```

```
%Principal Component 1 is the eigen vector with highest eigen value
P = sqrt(Y(12,12))*U12*X(:,12)'
%frobenius norm of the matrices
no = norm(Xnorm - P,'fro')
```

```
no = 20.4621
```

```
%Principal Component 2 has 2 eigen values with highest eigen values
P1 = sqrt(Y(12,12))*U12*X(:,12)'
P2 = sqrt(Y(11,11))*U11*X(:,11)'
P = P1 + P2
%frobenius norm of the matrices
no1 = norm(Xnorm- P, 'fro')
```

```
no1 = 17.5129
```

```
%Principal Component 3 has 3 eigen vectors with highest eigen values
P1 = sqrt(Y(12,12))*U12*X(:,12)'
P2 = sqrt(Y(11,11))*U11*X(:,11)'
P3 = sqrt(Y(10,10))*U10*X(:,10)'
P = P1+P2+P3
%frobenius norm of the matrices
no2 = norm(Xnorm- P, 'fro')
```

```
no2 = 14.6820
```

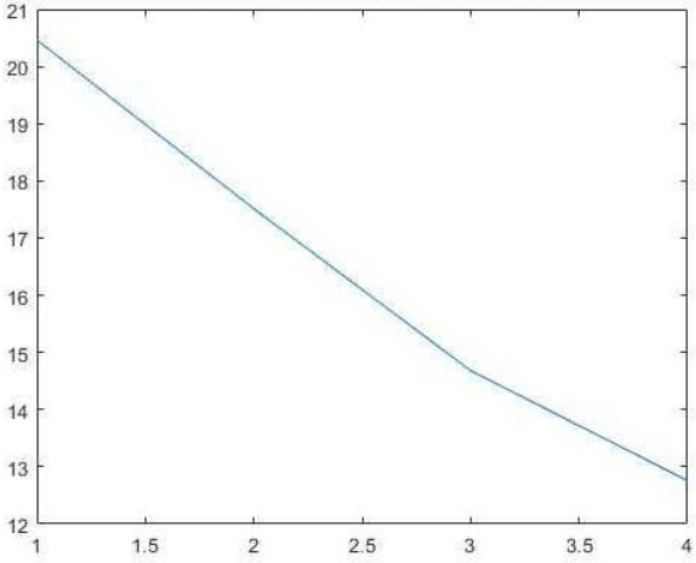
```
%Principal Component 4 has 4 eigen vectors with highest eigen values
P1 = sqrt(Y(12,12))*U12*X(:,12)'

P2 = sqrt(Y(11,11))*U11*X(:,11)'
P3 = sqrt(Y(10,10))*U10*X(:,10)'
P4 = sqrt(Y(9,9))*U9*X(:,9)'
P = P1+P2+P3+ P4
%frobenius norm of the matrices
no3 = norm(Xnorm- P, 'fro')
```

```
no3 = 12.7567
```

```
frobenius = [no no1 no2 no3]
```

```
frobenius =
   20.4621   17.5129   14.6820   12.7567
```

```
plot(frobenius)
```



Question 2:

The entire code for problem 2:

```
imfinfo('puppy.jpg')
I = imread('puppy.jpg')
size(I)
imshow(I)
I2 = rgb2gray(I)
imshow(I2)
imwrite(I2, 'puppy_gray.jpg', 'JPG')
size(I2)
I2 = double(I2)
%pup  = I2 * I2'
I2centered = (I2 - mean(I2))
for i= 1:448

I2centered(:,i) = I2centered(:,i)/std(I2centered(:,i))
end
pup = (I2centered' * I2centered)/448
U = []
[X , Y] = eig(pup)

for i = 1:448
    U = [U I2centered*X(:,i)/sqrt(Y(i,i))]
end
imshow(pup)
eigen = eig(pup)
max(eigen)

plot(eigen)
p = sum(eigen)
a = eigen
prompt = 'Enter the beta value'
beta = double(input(prompt))
co = 0
estimated = 1.00
while estimated > beta
    [a , estimated] = function23(a, p)
    co = co + 1
    if estimated <= beta
        disp(a)
        break
    end
end

lena = length(a)
P = zeros(448,500)
for i= 1:lena
    index = find(eigen == a(i))
    U = [I2centered*X(:,index)/sqrt(Y(index,index))]
    p1 = sqrt(Y(index,index))*U*X(:,index)'
    P = P + p1
end
disp(P)
imshow(P)

function [a] = rmvfunction(a,leas)
index = find(a==leas)
a(index) = []
end
```

```
function [newa ,y] = function23(a, p)
newa = rmvfunction(a, min(a))
newsum = sum(newa)
y = newsum/p
end
```

pasting the required output for the above code execution:

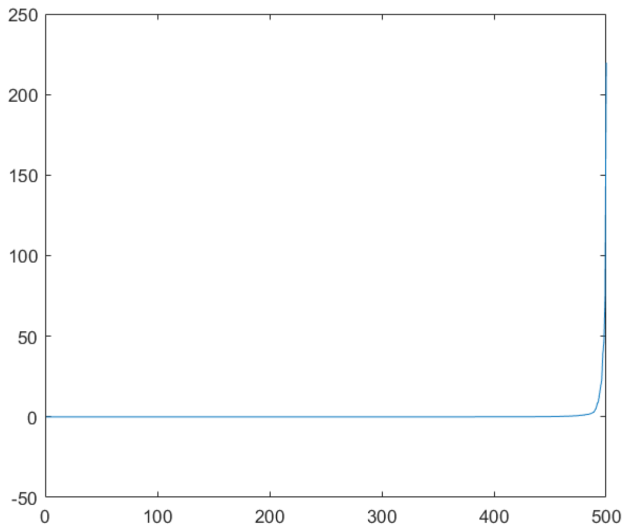
Puppy Image in matrix format after converting it into grey(Sample):

```
I2 = 448×500
    248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   247   247   247   247   247   247   247   247   248   248
   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   247   247   247   247   247   247   247   247   248   248
   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   247   247   247   247   247   247   247   247   248   248
   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   247   247   247   247   247   247   247   247   248   248
   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   247   247   247   247   247   247   247   247   248   248
   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   247   247   247   247   247   247   247   247   248   248
   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   247   247   247   247   247   247   247   247   248   248
   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   247   247   247   247   247   247   247   247   248   248
   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   248   248   248   248   248   248   248   248   248   248
   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248   248
248   248   248   248   248   248   248   248   248   248   248   248   248   248   247   247   247   247
247   247   247   247   248   248   248   248   248   248   248   248   248   248
```

Correlation matrix:

```
pup =
     0.9978     0.9968     0.9947     0.9901     0.9812     0.9698     0.9533     0.9423     0.9000     0.9000
0.9000     0.9000     0.9000     0.9000     0.9000     0.9000     0.8817     0.8817     0.8817     0.8817     0.8817
0.8817     0.8817     0.8817     0.8828     0.8828     0.8828     0.8828     0.8819     0.8819
    0.9968     0.9978     0.9965     0.9929     0.9859     0.9754     0.9610     0.9510     0.9053     0.9053
0.9053     0.9053     0.9053     0.9053     0.9053     0.9053     0.8868     0.8868     0.8868     0.8868     0.8868
0.8868     0.8868     0.8868     0.8880     0.8880     0.8880     0.8880     0.8871     0.8871
    0.9947     0.9965     0.9978     0.9958     0.9915     0.9837     0.9721     0.9630     0.9128     0.9128
0.9128     0.9128     0.9128     0.9128     0.9128     0.9128     0.8944     0.8944     0.8944     0.8944     0.8944
0.8944     0.8944     0.8944     0.8965     0.8965     0.8965     0.8965     0.8955     0.8955
    0.9901     0.9929     0.9958     0.9978     0.9953     0.9904     0.9807     0.9748     0.9189     0.9189
0.9189     0.9189     0.9189     0.9189     0.9189     0.9189     0.9004     0.9004     0.9004     0.9004     0.9004
0.9004     0.9004     0.9004     0.9032     0.9032     0.9032     0.9032     0.9022     0.9022
    0.9812     0.9859     0.9915     0.9953     0.9978     0.9958     0.9903     0.9853     0.9238     0.9238
0.9238     0.9238     0.9238     0.9238     0.9238     0.9238     0.9053     0.9053     0.9053     0.9053     0.9053
0.9053     0.9053     0.9053     0.9092     0.9092     0.9092     0.9092     0.9082     0.9082
    0.9698     0.9754     0.9837     0.9904     0.9958     0.9978     0.9955     0.9927     0.9255     0.9255
0.9255     0.9255     0.9255     0.9255     0.9255     0.9255     0.9072     0.9072     0.9072     0.9072     0.9072
0.9072     0.9072     0.9072     0.9125     0.9125     0.9125     0.9125     0.9114     0.9114
    0.9533     0.9610     0.9721     0.9807     0.9903     0.9955     0.9978     0.9960     0.9233     0.9233
0.9233     0.9233     0.9233     0.9233     0.9233     0.9233     0.9051     0.9051     0.9051     0.9051     0.9051
0.9051     0.9051     0.9051     0.9112     0.9112     0.9112     0.9112     0.9100     0.9100
    0.9423     0.9510     0.9630     0.9748     0.9853     0.9927     0.9960     0.9978     0.9206     0.9206
0.9206     0.9206     0.9206     0.9206     0.9206     0.9206     0.9025     0.9025     0.9025     0.9025     0.9025
0.9025     0.9025     0.9025     0.9090     0.9090     0.9090     0.9090     0.9078     0.9078
    0.9000     0.9053     0.9128     0.9189     0.9238     0.9255     0.9233     0.9206     0.9978     0.9978
0.9978     0.9978     0.9978     0.9978     0.9978     0.9978     0.9480     0.9480     0.9480     0.9480     0.9480
0.9480     0.9480     0.9480     0.9364     0.9364     0.9364     0.9364     0.9321     0.9321
    0.9000     0.9053     0.9128     0.9189     0.9238     0.9255     0.9233     0.9206     0.9978     0.9978
0.9978     0.9978     0.9978     0.9978     0.9978     0.9978     0.9480     0.9480     0.9480     0.9480     0.9480
0.9480     0.9480     0.9480     0.9364     0.9364     0.9364     0.9364     0.9321     0.9321
```

Plot of Eigen Values:



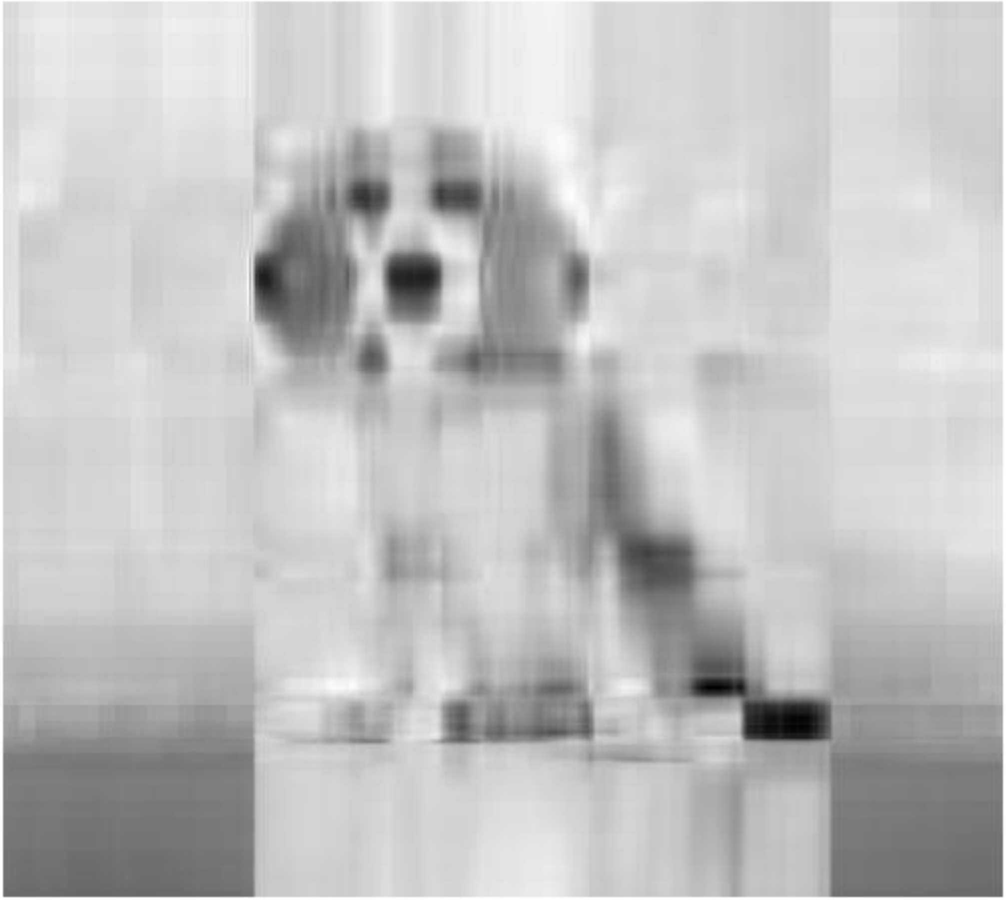
When Beta = 0.1

Value of k was 9 which means the top 9 eigen values were contributing almost 90% of the variance

Reconstructing the matrix using these 9 patterns:
Reconstructed Matrix(Sample)

```
  P = 448*500
    0.5495    0.5521    0.5587    0.5635    0.5683    0.5724    0.5720    0.5707    0.8262    0.8262
0.8262    0.8262    0.8262    0.8262    0.8262    0.8262    0.9604    0.9604    0.9604    0.9604    0.9604
0.9604    0.9604    0.9604    0.9708    0.9708    0.9708    0.9708    0.9893    0.9893
    0.5495    0.5521    0.5587    0.5635    0.5683    0.5724    0.5720    0.5707    0.8262    0.8262
0.8262    0.8262    0.8262    0.8262    0.8262    0.8262    0.9604    0.9604    0.9604    0.9604    0.9604
0.9604    0.9604    0.9604    0.9708    0.9708    0.9708    0.9708    0.9893    0.9893
    0.5495    0.5521    0.5587    0.5635    0.5683    0.5724    0.5720    0.5707    0.8262    0.8262
0.8262    0.8262    0.8262    0.8262    0.8262    0.8262    0.9604    0.9604    0.9604    0.9604    0.9604
0.9604    0.9604    0.9604    0.9708    0.9708    0.9708    0.9708    0.9893    0.9893
    0.5496    0.5523    0.5589    0.5636    0.5685    0.5726    0.5722    0.5709    0.8269    0.8269
0.8269    0.8269    0.8269    0.8269    0.8269    0.8269    0.9608    0.9608    0.9608    0.9608    0.9608
0.9608    0.9608    0.9608    0.9711    0.9711    0.9711    0.9711    0.9894    0.9894
    0.5496    0.5523    0.5589    0.5636    0.5685    0.5726    0.5722    0.5709    0.8269    0.8269
0.8269    0.8269    0.8269    0.8269    0.8269    0.8269    0.9608    0.9608    0.9608    0.9608    0.9608
0.9608    0.9608    0.9608    0.9711    0.9711    0.9711    0.9711    0.9894    0.9894
    0.5496    0.5523    0.5589    0.5636    0.5685    0.5726    0.5722    0.5709    0.8269    0.8269
0.8269    0.8269    0.8269    0.8269    0.8269    0.8269    0.9608    0.9608    0.9608    0.9608    0.9608
0.9608    0.9608    0.9608    0.9711    0.9711    0.9711    0.9711    0.9894    0.9894
    0.5498    0.5524    0.5590    0.5638    0.5686    0.5727    0.5723    0.5710    0.8275    0.8275
0.8275    0.8275    0.8275    0.8275    0.8275    0.8275    0.9612    0.9612    0.9612    0.9612    0.9612
0.9612    0.9612    0.9612    0.9714    0.9714    0.9714    0.9714    0.9895    0.9895
    0.5498    0.5524    0.5590    0.5638    0.5686    0.5727    0.5723    0.5710    0.8275    0.8275
0.8275    0.8275    0.8275    0.8275    0.8275    0.8275    0.9612    0.9612    0.9612    0.9612    0.9612
0.9612    0.9612    0.9612    0.9714    0.9714    0.9714    0.9714    0.9895    0.9895
    0.6196    0.6227    0.6297    0.6349    0.6400    0.6442    0.6435    0.6420    0.8951    0.8951
0.8951    0.8951    0.8951    0.8951    0.8951    0.8951    1.0272    1.0272    1.0272    1.0272    1.0272
1.0272    1.0272    1.0272    1.0381    1.0381    1.0381    1.0381    1.0575    1.0575
    0.6196    0.6227    0.6297    0.6349    0.6400    0.6442    0.6435    0.6420    0.8951    0.8951
0.8951    0.8951    0.8951    0.8951    0.8951    0.8951    1.0272    1.0272    1.0272    1.0272    1.0272
1.0272    1.0272    1.0272    1.0381    1.0381    1.0381    1.0381    1.0575    1.0575
```

Image generated by using the regenerated matrix is:



Frobenius norm when beta = 0.1 is `1.0971e+05`

When Beta = 0.05

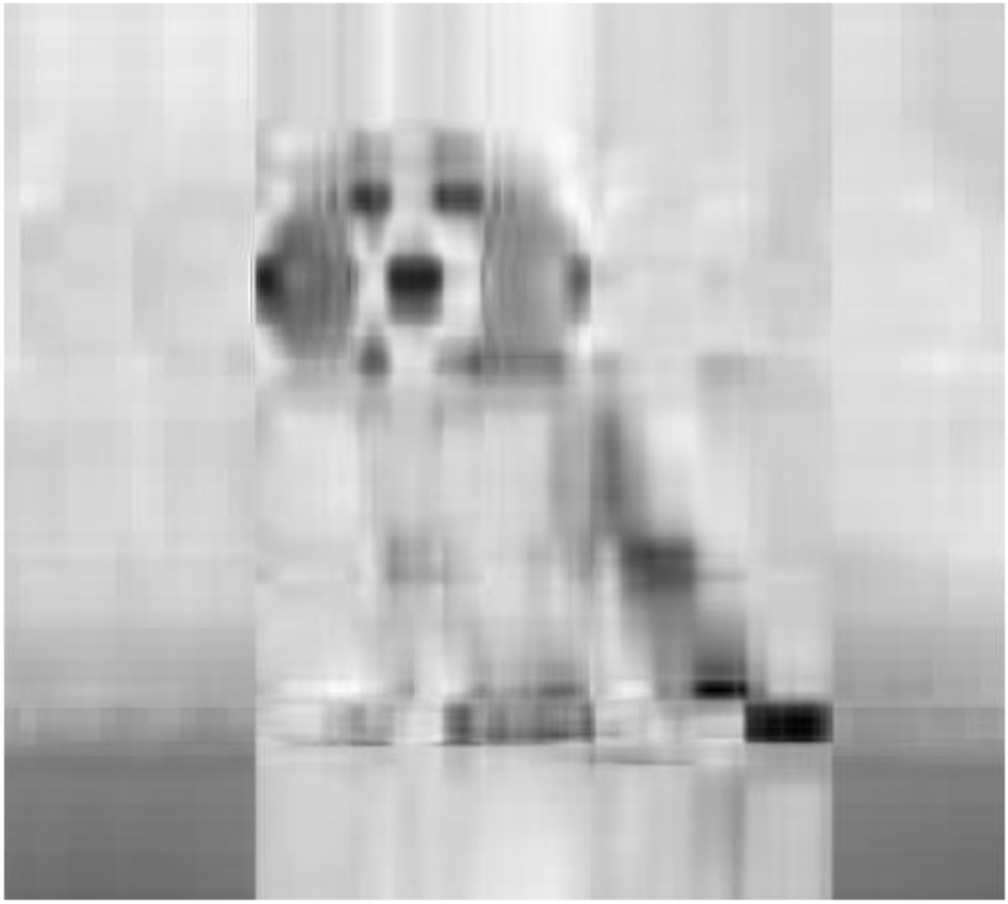
Value of k was 12 which means the top 12 eigen values were contributing almost 95% of the variance

Reconstructing the matrix using these 12 patterns:
Reconstructed Matrix(Sample)

```
P =
    0.5494    0.5520    0.5597    0.5652    0.5712    0.5770    0.5774    0.5765    0.8491    0.8491
0.8491    0.8491    0.8491    0.8491    0.8491    0.8491    0.9500    0.9500    0.9500    0.9500    0.9500
0.9500    0.9500    0.9500    0.9661    0.9661    0.9661    0.9661    0.9986    0.9986
    0.5494    0.5520    0.5597    0.5652    0.5712    0.5770    0.5774    0.5765    0.8491    0.8491
0.8491    0.8491    0.8491    0.8491    0.8491    0.8491    0.9500    0.9500    0.9500    0.9500    0.9500
0.9500    0.9500    0.9500    0.9661    0.9661    0.9661    0.9661    0.9986    0.9986
    0.5494    0.5520    0.5597    0.5652    0.5712    0.5770    0.5774    0.5765    0.8491    0.8491
0.8491    0.8491    0.8491    0.8491    0.8491    0.8491    0.9500    0.9500    0.9500    0.9500    0.9500
0.9500    0.9500    0.9500    0.9661    0.9661    0.9661    0.9661    0.9986    0.9986
    0.5496    0.5522    0.5600    0.5655    0.5715    0.5773    0.5776    0.5768    0.8495    0.8495
0.8495    0.8495    0.8495    0.8495    0.8495    0.8495    0.9503    0.9503    0.9503    0.9503    0.9503
0.9503    0.9503    0.9503    0.9662    0.9662    0.9662    0.9662    0.9984    0.9984
    0.5496    0.5522    0.5600    0.5655    0.5715    0.5773    0.5776    0.5768    0.8495    0.8495
0.8495    0.8495    0.8495    0.8495    0.8495    0.8495    0.9503    0.9503    0.9503    0.9503    0.9503
0.9503    0.9503    0.9503    0.9662    0.9662    0.9662    0.9662    0.9984    0.9984
    0.5496    0.5522    0.5600    0.5655    0.5715    0.5773    0.5776    0.5768    0.8495    0.8495
0.8495    0.8495    0.8495    0.8495    0.8495    0.8495    0.9503    0.9503    0.9503    0.9503    0.9503
0.9503    0.9503    0.9503    0.9662    0.9662    0.9662    0.9662    0.9984    0.9984
    0.5499    0.5525    0.5602    0.5658    0.5718    0.5775    0.5779    0.5770    0.8499    0.8499
0.8499    0.8499    0.8499    0.8499    0.8499    0.8499    0.9507    0.9507    0.9507    0.9507    0.9507
0.9507    0.9507    0.9507    0.9662    0.9662    0.9662    0.9662    0.9981    0.9981
```

```
    0.5499    0.5525    0.5602    0.5658    0.5718    0.5775    0.5779    0.5770    0.8499    0.8499
0.8499    0.8499    0.8499    0.8499    0.8499    0.8499    0.9507    0.9507    0.9507    0.9507    0.9507
0.9507    0.9507    0.9507    0.9662    0.9662    0.9662    0.9662    0.9981    0.9981
    0.6105    0.6134    0.6213    0.6269    0.6329    0.6383    0.6382    0.6369    0.9195    0.9195
0.9195    0.9195    0.9195    0.9195    0.9195    0.9195    1.0305    1.0305    1.0305    1.0305    1.0305
1.0305    1.0305    1.0305    1.0462    1.0462    1.0462    1.0462    1.0767    1.0767
    0.6105    0.6134    0.6213    0.6269    0.6329    0.6383    0.6382    0.6369    0.9195    0.9195
0.9195    0.9195    0.9195    0.9195    0.9195    0.9195    1.0305    1.0305    1.0305    1.0305    1.0305
1.0305    1.0305    1.0305    1.0462    1.0462    1.0462    1.0462    1.0767    1.0767
```

Image generated by using the regenerated matrix is:



Frobenius norm when beta = 0.05 is `1.0970e+05`

When Beta = 0.01

Value of k was 41 which means the top 41 eigen values were contributing almost 99% of the variance

Reconstructing the matrix using these 41 patterns:
Reconstructed Matrix(Sample)

```
P =
    0.0104    0.0101    0.0090    0.0080    0.0066    0.0050    0.0037    0.0030   -0.0068   -0.0068   -
0.0068   -0.0068   -0.0068   -0.0068   -0.0068   -0.0068    0.0009    0.0009    0.0009    0.0009    0.0009
0.0009    0.0009    0.0009    0.0045    0.0045    0.0045    0.0045    0.0055    0.0055
```

```
    0.0104    0.0101    0.0090    0.0080    0.0066    0.0050    0.0037    0.0030   -0.0068   -0.0068   -
0.0068   -0.0068   -0.0068   -0.0068   -0.0068   -0.0068    0.0009    0.0009    0.0009    0.0009    0.0009
0.0009    0.0009    0.0009    0.0045    0.0045    0.0045    0.0045    0.0055    0.0055
    0.0104    0.0101    0.0090    0.0080    0.0066    0.0050    0.0037    0.0030   -0.0068   -0.0068   -
0.0068   -0.0068   -0.0068   -0.0068   -0.0068   -0.0068    0.0009    0.0009    0.0009    0.0009    0.0009
0.0009    0.0009    0.0009    0.0045    0.0045    0.0045    0.0045    0.0055    0.0055
    0.0104    0.0101    0.0090    0.0080    0.0066    0.0050    0.0037    0.0030   -0.0068   -0.0068   -
0.0068   -0.0068   -0.0068   -0.0068   -0.0068   -0.0068    0.0009    0.0009    0.0009    0.0009    0.0009
0.0009    0.0009    0.0009    0.0044    0.0044    0.0044    0.0044    0.0055    0.0055
    0.0104    0.0101    0.0090    0.0080    0.0066    0.0050    0.0037    0.0030   -0.0068   -0.0068   -
0.0068   -0.0068   -0.0068   -0.0068   -0.0068   -0.0068    0.0009    0.0009    0.0009    0.0009    0.0009
0.0009    0.0009    0.0009    0.0044    0.0044    0.0044    0.0044    0.0055    0.0055
    0.0104    0.0101    0.0090    0.0080    0.0066    0.0050    0.0037    0.0030   -0.0068   -0.0068   -
0.0068   -0.0068   -0.0068   -0.0068   -0.0068   -0.0068    0.0009    0.0009    0.0009    0.0009    0.0009
0.0009    0.0009    0.0009    0.0044    0.0044    0.0044    0.0044    0.0055    0.0055
    0.0104    0.0101    0.0090    0.0080    0.0066    0.0050    0.0037    0.0030   -0.0068   -0.0068   -
0.0068   -0.0068   -0.0068   -0.0068   -0.0068   -0.0068    0.0009    0.0009    0.0009    0.0009    0.0009
0.0009    0.0009    0.0009    0.0044    0.0044    0.0044    0.0044    0.0055    0.0055
    0.0104    0.0101    0.0090    0.0080    0.0066    0.0050    0.0037    0.0030   -0.0068   -0.0068   -
0.0068   -0.0068   -0.0068   -0.0068   -0.0068   -0.0068    0.0009    0.0009    0.0009    0.0009    0.0009
0.0009    0.0009    0.0009    0.0044    0.0044    0.0044    0.0044    0.0055    0.0055
    0.0049    0.0048    0.0043    0.0038    0.0031    0.0024    0.0018    0.0014   -0.0032   -0.0032   -
0.0032   -0.0032   -0.0032   -0.0032   -0.0032   -0.0032    0.0004    0.0004    0.0004    0.0004    0.0004
0.0004    0.0004    0.0004    0.0021    0.0021    0.0021    0.0021    0.0026    0.0026
    0.0049    0.0048    0.0043    0.0038    0.0031    0.0024    0.0018    0.0014   -0.0032   -0.0032   -
0.0032   -0.0032   -0.0032   -0.0032   -0.0032   -0.0032    0.0004    0.0004    0.0004    0.0004    0.0004
0.0004    0.0004    0.0004    0.0021    0.0021    0.0021    0.0021    0.0026    0.0026
```

Image generated by using the regenerated matrix is:

Frobenius norm when beta = 0.01 is 1.0970e+05