Intro to ML: Homework 0

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1 Task 1

Since my machine already has Miniconda installed, here is the output for:

```
(base) gonz495@WE40210 dlintro % conda info
```

```
     active environment : base
    active env location : /Users/gonz495/miniconda3
            shell level : 1
       user config file : /Users/gonz495/.condarc
 populated config files : /Users/gonz495/.condarc
          conda version : 23.7.3
    conda-build version : not installed
         python version : 3.10.10.final.0
       virtual packages : __archspec=1=x86_64
                          __osx=10.16=0
                          __unix=0=0
      base environment : /Users/gonz495/miniconda3  (writable)
     conda av data dir : /Users/gonz495/miniconda3/etc/conda
 conda av metadata url : None
          channel URLs : https://repo.anaconda.com/pkgs/main/osx-64
                         https://repo.anaconda.com/pkgs/main/noarch
                         https://repo.anaconda.com/pkgs/r/osx-64
                         https://repo.anaconda.com/pkgs/r/noarch
         package cache : /Users/gonz495/miniconda3/pkgs
                         /Users/gonz495/.conda/pkgs
      envs directories : /Users/gonz495/miniconda3/envs
                         /Users/gonz495/.conda/envs
              platform : osx-64
            user-agent : conda/23.7.3 requests/2.28.1 CPython/3.10.10 \
                         Darwin/22.6.0 OSX/10.16
                UID:GID : 1018750640:2016721313
             netrc file : None
           offline mode : False
```

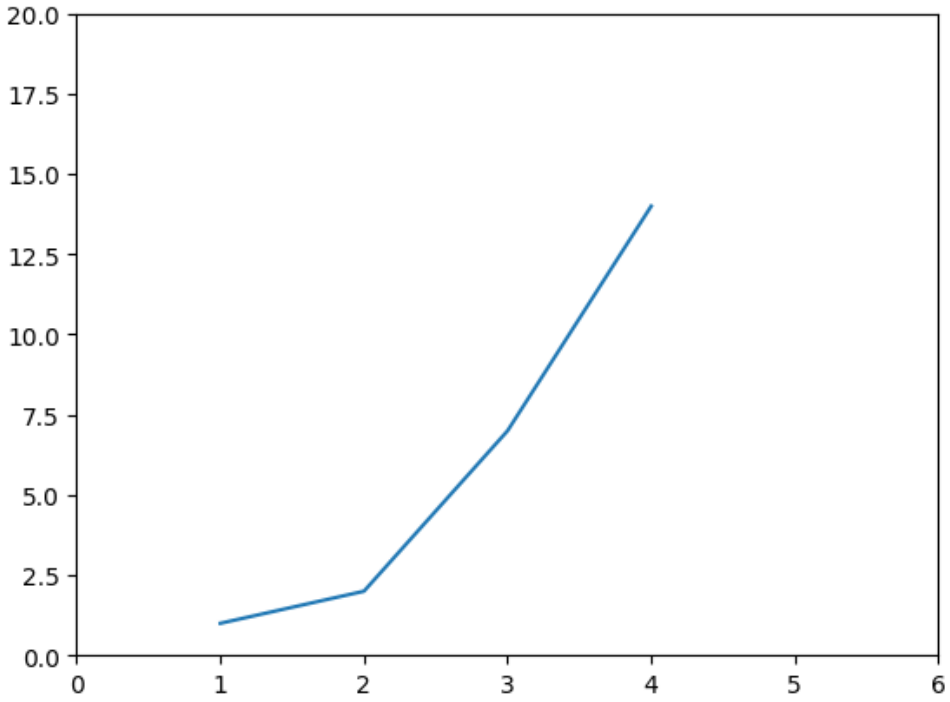
2 Tasks 2-6

Using PyCharm (Personally prefer VS Code with a Mac OS), the attached PDF at the bottom shows my most recent run through all these cells have been executed at once from the Jupyter Notebook uploaded in my public repository for this class here (GitHub account): `http://github.com/cargonriv/IntroDL/HW0.ipynb`

In [1]:

```
import numpy
import scipy
import pandas as pd
from matplotlib import pyplot as plt

plt.plot([1,2,3,4], [1,2,7,14])
plt.axis([0, 6, 0, 20])
plt.show()
```



In [2]:

```
a = 1 * numpy.random.randint(1000000) + numpy.random.randint(1000000, size=(10, 5, 5))
b = 1 * numpy.random.randint(1000000) + numpy.random.randint(1000000, size=(5, 5))
c = numpy.random.randint(1000000, size=(10, 5, 5))
v = numpy.random.randint(1000000, size=5)
numpy.random.shuffle(a)
numpy.random.shuffle(b)
numpy.random.shuffle(c)
numpy.random.shuffle(v)

corr_df = pd.DataFrame(index=["correlation"], columns=[s for s in range(a.shape[0] * a.s
hape[1])])

corr_counter: int = 0

for i, j in zip(a, c):
    for h, k in zip(i, j):

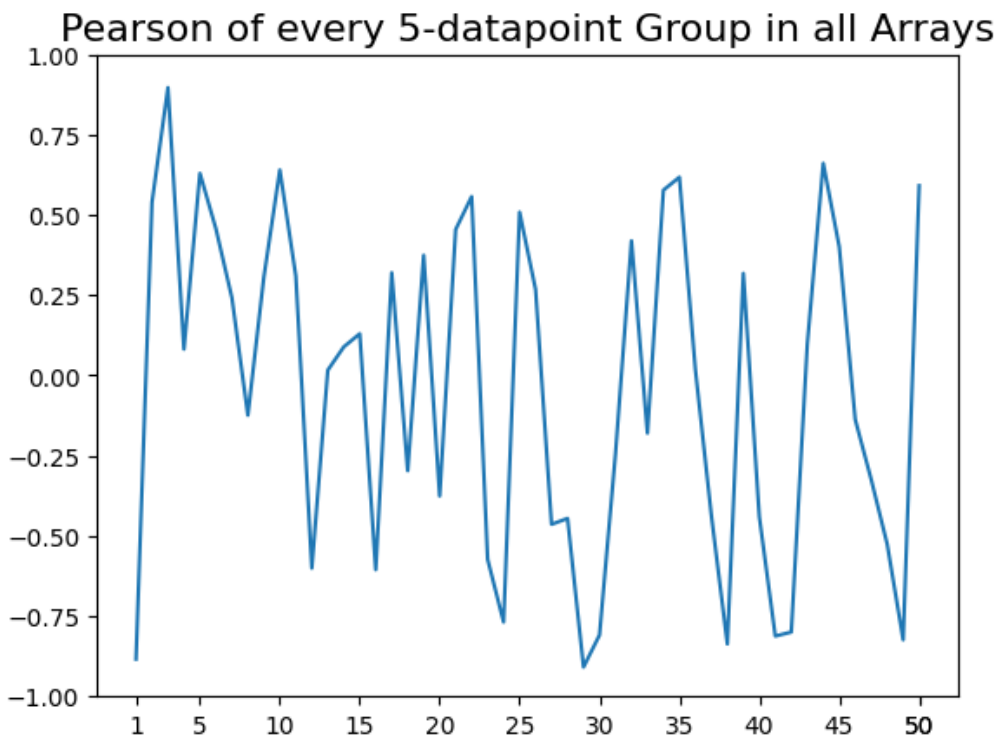
        corr_df.iloc[0, [corr_counter]] =\
            scipy.stats.pearsonr(h, k)[0]

        corr_counter += 1
corr_df.columns += 1

plt.xticks([1] + [g for g in range(5, corr_df.shape[1] + 1, 5)] + [corr_df.shape[1]])
plt.title('Pearson of every 5-datapoint Group in all Arrays', fontsize=16)
plt.plot(corr_df.T)
plt.ylim(-1, 1)
# corr_df.T.plot()
```

Out[2]:

```
(-1.0, 1.0)
```

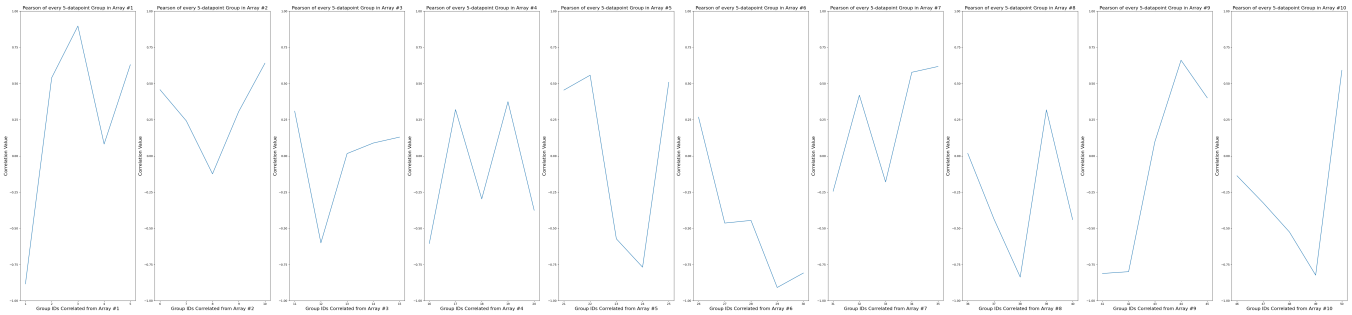


In [3]:

```
# Create subplots: 2 rows and 5 columns, for a total of 10 subplots
fig, axes = plt.subplots(1, 10, figsize=(65, 15))

# Flatten the axes array for easy iteration
axes = axes.flatten()

# Plot each group of 5 points on a separate subplot
for i in range(10):
    axes[i].plot(corr_df.iloc[:, i * 5 : (i+1) * 5].T)
    axes[i].set_xticks(corr_df.iloc[:, i * 5 : (i+1) * 5].T.index.values)
    axes[i].set_title(f'Pearson of every 5-datapoint Group in Array #{i+1}', fontsize=16)
    axes[i].set_xlabel(f'Group IDs Correlated from Array #{i+1}', fontsize=16)
    axes[i].set_ylabel('Correlation Value', fontsize=16)
    axes[i].set_ylim(-1, 1)
    axes[i].tick_params(axis='both', which='minor', labelsize=12)
# Show the plots
plt.tight_layout()
plt.show()
```



In [4]:

```
numpy.ndim(a)
```

Out[4]:

```
3
```

In [5]:

```
numpy.size(a)
```

Out[5]:

```
250
```

In [6]:

```
numpy.shape(a)
```

Out[6]:

```
(10, 5, 5)
```

In [7]:

```
n=0; a.shape[n-1]
```

Out[7]:

```
5
```

In [8]:

```
numpy.array([[1., 2., 3.], [4., 5., 6.]])
```

Out[8]:

```
array([[1., 2., 3.],
       [4., 5., 6.]])
```

In [9]:

```
o, p, n, m = "m", "n", "o", "p"; numpy.block([[o, m], [p, n]])
```

Out[9]:

```
array([['m', 'p'],
       ['n', 'o']], dtype='<U1')
```

In [10]:

```
a[-1]
```

Out[10]:

```
array([[1101804, 1508997, 1654952, 1552711, 1162481],
       [1563476, 1658582, 1241078, 1139909,  973681],
       [1488171,  975248, 1836697, 1561443, 1099087],
       [1099545,  936733, 1844351, 1278038, 1375810],
       [1744610, 1694214, 1009046, 1045958, 1623252]])
```

In [11]:

```
a[1, 4]
```

Out[11]:

```
array([1140924, 1308549, 1728018, 1672535, 1140901])
```

In [12]:

```
a[1, :], a[1]
```

Out[12]:

```
(array([[1574276, 1095978, 1501457, 1319208, 1220988],
        [1906489, 1363057, 1846672, 1170888, 1079171],
        [1691723, 1587524, 1303479, 1487619, 1885149],
        [1015545, 1583913, 1426965, 1057042, 1862348],
        [1140924, 1308549, 1728018, 1672535, 1140901]]),
 array([[1574276, 1095978, 1501457, 1319208, 1220988],
        [1906489, 1363057, 1846672, 1170888, 1079171],
        [1691723, 1587524, 1303479, 1487619, 1885149],
        [1015545, 1583913, 1426965, 1057042, 1862348],
```

```
        [1140924, 1308549, 1728018, 1672535, 1140901]]))
```

In [13]:

```
a[0:5, :], a[0:5], a[:5]
```

Out[13]:

```
(array([[[1333166, 1572589, 1762176, 1183624, 1529656],
         [1851593, 1815053, 1375248, 1726595, 1730404],
         [1316265, 1053595,  966590, 1046383, 1484121],
         [ 984608, 1199773, 1414266, 1654357, 1862733],
         [1703046, 1661303, 1500530, 1573033, 1037890]],

        [[1574276, 1095978, 1501457, 1319208, 1220988],
         [1906489, 1363057, 1846672, 1170888, 1079171],
         [1691723, 1587524, 1303479, 1487619, 1885149],
         [1015545, 1583913, 1426965, 1057042, 1862348],
         [1140924, 1308549, 1728018, 1672535, 1140901]],

        [[1040146, 1442220, 1813791, 1779269, 1844805],
         [1457408, 1579285, 1264223, 1140315, 1654840],
         [1540211, 1789707,  941945, 1336026, 1649883],
         [1529542, 1040760, 1635968,  967259, 1545622],
         [1766041, 1103719, 1340656, 1827259, 1759468]],

        [[ 946625, 1071874, 1217317, 1253059, 1645214],
         [1771739, 1360594, 1693264, 1099393, 1625469],
         [1899062, 1234257, 1758411, 1808244, 1621284],
         [1111985, 1906562, 1442910, 1384659, 1205922],
         [1502421, 1596701, 1691348, 1688786, 1107790]],

        [[1084486, 1420500,  951261, 1409876, 1539461],
         [1373414, 1918707, 1381903, 1492167, 1542554],
         [1492249, 1504673, 1118936,  948957, 1057805],
         [1343545, 1297526, 1340025, 1209363, 1930811],
         [1192370, 1592099, 1697326, 1791227, 1392562]]]),
 array([[[1333166, 1572589, 1762176, 1183624, 1529656],
         [1851593, 1815053, 1375248, 1726595, 1730404],
         [1316265, 1053595,  966590, 1046383, 1484121],
         [ 984608, 1199773, 1414266, 1654357, 1862733],
         [1703046, 1661303, 1500530, 1573033, 1037890]],

        [[1574276, 1095978, 1501457, 1319208, 1220988],
         [1906489, 1363057, 1846672, 1170888, 1079171],
         [1691723, 1587524, 1303479, 1487619, 1885149],
         [1015545, 1583913, 1426965, 1057042, 1862348],
         [1140924, 1308549, 1728018, 1672535, 1140901]],

        [[1040146, 1442220, 1813791, 1779269, 1844805],
         [1457408, 1579285, 1264223, 1140315, 1654840],
         [1540211, 1789707,  941945, 1336026, 1649883],
         [1529542, 1040760, 1635968,  967259, 1545622],
         [1766041, 1103719, 1340656, 1827259, 1759468]],

        [[ 946625, 1071874, 1217317, 1253059, 1645214],
         [1771739, 1360594, 1693264, 1099393, 1625469],
         [1899062, 1234257, 1758411, 1808244, 1621284],
         [1111985, 1906562, 1442910, 1384659, 1205922],
         [1502421, 1596701, 1691348, 1688786, 1107790]],

        [[1084486, 1420500,  951261, 1409876, 1539461],
         [1373414, 1918707, 1381903, 1492167, 1542554],
         [1492249, 1504673, 1118936,  948957, 1057805],
         [1343545, 1297526, 1340025, 1209363, 1930811],
         [1192370, 1592099, 1697326, 1791227, 1392562]]]),
 array([[[1333166, 1572589, 1762176, 1183624, 1529656],
         [1851593, 1815053, 1375248, 1726595, 1730404],
         [1316265, 1053595,  966590, 1046383, 1484121],
         [ 984608, 1199773, 1414266, 1654357, 1862733],
         [1703046, 1661303, 1500530, 1573033, 1037890]],

        [[1574276, 1095978, 1501457, 1319208, 1220988],
```

```
        [[1574276, 1095978, 1501457, 1519208, 1220988],
         [1906489, 1363057, 1846672, 1170888, 1079171],
         [1691723, 1587524, 1303479, 1487619, 1885149],
         [1015545, 1583913, 1426965, 1057042, 1862348],
         [1140924, 1308549, 1728018, 1672535, 1140901]],

        [[1040146, 1442220, 1813791, 1779269, 1844805],
         [1457408, 1579285, 1264223, 1140315, 1654840],
         [1540211, 1789707,  941945, 1336026, 1649883],
         [1529542, 1040760, 1635968,  967259, 1545622],
         [1766041, 1103719, 1340656, 1827259, 1759468]],

        [[ 946625, 1071874, 1217317, 1253059, 1645214],
         [1771739, 1360594, 1693264, 1099393, 1625469],
         [1899062, 1234257, 1758411, 1808244, 1621284],
         [1111985, 1906562, 1442910, 1384659, 1205922],
         [1502421, 1596701, 1691348, 1688786, 1107790]],

        [[1084486, 1420500,  951261, 1409876, 1539461],
         [1373414, 1918707, 1381903, 1492167, 1542554],
         [1492249, 1504673, 1118936,  948957, 1057805],
         [1343545, 1297526, 1340025, 1209363, 1930811],
         [1192370, 1592099, 1697326, 1791227, 1392562]]]))
```

In [14]:

```
a[-5:]
```

Out[14]:

```
array([[[1381233, 1061264, 1474423, 1545998, 1688246],
        [1715152, 1674344, 1265083, 1816093, 1330216],
        [1517395, 1788509, 1018697, 1085967, 1700539],
        [1823260, 1701446, 1217793, 1091541, 1213386],
        [1102766, 1837942, 1311743, 1200064, 1665033]],

       [[1557863, 1537943,  957853,  974471, 1612175],
        [1021752, 1318286, 1784634, 1248913, 1788500],
        [1759678, 1432700,  967396, 1645855, 1249134],
        [1137195, 1667385, 1537180, 1065200, 1679509],
        [1274707,  964638, 1826730, 1772338, 1576104]],

       [[1893580, 1097519, 1589644, 1339521, 1254992],
        [1190201, 1086195, 1904122, 1688603, 1300525],
        [1252150, 1170372, 1239828, 1073623, 1008399],
        [1351539, 1298236, 1285932, 1483235, 1305192],
        [1374916, 1271813, 1884451, 1427769, 1858424]],

       [[1653711, 1598034, 1332210, 1806313,  988869],
        [1833353, 1804103, 1914530, 1635238, 1831884],
        [1781412, 1567835, 1576848, 1270079, 1226014],
        [1927021, 1573684, 1291355, 1679571, 1684789],
        [1529556, 1831723, 1119955, 1821060, 1093759]],

       [[1101804, 1508997, 1654952, 1552711, 1162481],
        [1563476, 1658582, 1241078, 1139909,  973681],
        [1488171,  975248, 1836697, 1561443, 1099087],
        [1099545,  936733, 1844351, 1278038, 1375810],
        [1744610, 1694214, 1009046, 1045958, 1623252]]])
```

In [15]:

```
a[0:3, 4:9]
```

Out[15]:

```
array([[[1703046, 1661303, 1500530, 1573033, 1037890]],

       [[1140924, 1308549, 1728018, 1672535, 1140901]],

       [[1766041, 1103719, 1340656, 1827259, 1759468]]])
```

In [16]:

```
a[numpy.ix_([1, 3, 4], [0, 2])]
```

Out[16]:

```
array([[[1574276, 1095978, 1501457, 1319208, 1220988],
        [1691723, 1587524, 1303479, 1487619, 1885149]],

       [[ 946625, 1071874, 1217317, 1253059, 1645214],
        [1899062, 1234257, 1758411, 1808244, 1621284]],

       [[1084486, 1420500,  951261, 1409876, 1539461],
        [1492249, 1504673, 1118936,  948957, 1057805]]])
```

In [17]:

```
a[2:21:2,:]
```

Out[17]:

```
array([[[1040146, 1442220, 1813791, 1779269, 1844805],
        [1457408, 1579285, 1264223, 1140315, 1654840],
        [1540211, 1789707,  941945, 1336026, 1649883],
        [1529542, 1040760, 1635968,  967259, 1545622],
        [1766041, 1103719, 1340656, 1827259, 1759468]],

       [[1084486, 1420500,  951261, 1409876, 1539461],
        [1373414, 1918707, 1381903, 1492167, 1542554],
        [1492249, 1504673, 1118936,  948957, 1057805],
        [1343545, 1297526, 1340025, 1209363, 1930811],
        [1192370, 1592099, 1697326, 1791227, 1392562]],

       [[1557863, 1537943,  957853,  974471, 1612175],
        [1021752, 1318286, 1784634, 1248913, 1788500],
        [1759678, 1432700,  967396, 1645855, 1249134],
        [1137195, 1667385, 1537180, 1065200, 1679509],
        [1274707,  964638, 1826730, 1772338, 1576104]],

       [[1653711, 1598034, 1332210, 1806313,  988869],
        [1833353, 1804103, 1914530, 1635238, 1831884],
        [1781412, 1567835, 1576848, 1270079, 1226014],
        [1927021, 1573684, 1291355, 1679571, 1684789],
        [1529556, 1831723, 1119955, 1821060, 1093759]]])
```

In [18]:

```
a[::2, :]
```

Out[18]:

```
array([[[1333166, 1572589, 1762176, 1183624, 1529656],
        [1851593, 1815053, 1375248, 1726595, 1730404],
        [1316265, 1053595,  966590, 1046383, 1484121],
        [ 984608, 1199773, 1414266, 1654357, 1862733],
        [1703046, 1661303, 1500530, 1573033, 1037890]],

       [[1040146, 1442220, 1813791, 1779269, 1844805],
        [1457408, 1579285, 1264223, 1140315, 1654840],
        [1540211, 1789707,  941945, 1336026, 1649883],
        [1529542, 1040760, 1635968,  967259, 1545622],
        [1766041, 1103719, 1340656, 1827259, 1759468]],

       [[1084486, 1420500,  951261, 1409876, 1539461],
        [1373414, 1918707, 1381903, 1492167, 1542554],
        [1492249, 1504673, 1118936,  948957, 1057805],
        [1343545, 1297526, 1340025, 1209363, 1930811],
        [1192370, 1592099, 1697326, 1791227, 1392562]],

       [[1557863, 1537943,  957853,  974471, 1612175],
        [1021752, 1318286, 1784634, 1248913, 1788500],
        [1759678, 1432700,  967396, 1645855, 1249134],
        [1137195, 1667385, 1537180, 1065200, 1679509],
        [1274707,  964638, 1826730, 1772338, 1576104]],
```

```
       [[1653711, 1598034, 1332210, 1806313,  988869],
        [1833353, 1804103, 1914530, 1635238, 1831884],
        [1781412, 1567835, 1576848, 1270079, 1226014],
        [1927021, 1573684, 1291355, 1679571, 1684789],
        [1529556, 1831723, 1119955, 1821060, 1093759]]])
```

In [19]:

```
a[::-1,:]
```

Out[19]:

```
array([[[1101804, 1508997, 1654952, 1552711, 1162481],
        [1563476, 1658582, 1241078, 1139909,  973681],
        [1488171,  975248, 1836697, 1561443, 1099087],
        [1099545,  936733, 1844351, 1278038, 1375810],
        [1744610, 1694214, 1009046, 1045958, 1623252]],

       [[1653711, 1598034, 1332210, 1806313,  988869],
        [1833353, 1804103, 1914530, 1635238, 1831884],
        [1781412, 1567835, 1576848, 1270079, 1226014],
        [1927021, 1573684, 1291355, 1679571, 1684789],
        [1529556, 1831723, 1119955, 1821060, 1093759]],

       [[1893580, 1097519, 1589644, 1339521, 1254992],
        [1190201, 1086195, 1904122, 1688603, 1300525],
        [1252150, 1170372, 1239828, 1073623, 1008399],
        [1351539, 1298236, 1285932, 1483235, 1305192],
        [1374916, 1271813, 1884451, 1427769, 1858424]],

       [[1557863, 1537943,  957853,  974471, 1612175],
        [1021752, 1318286, 1784634, 1248913, 1788500],
        [1759678, 1432700,  967396, 1645855, 1249134],
        [1137195, 1667385, 1537180, 1065200, 1679509],
        [1274707,  964638, 1826730, 1772338, 1576104]],

       [[1381233, 1061264, 1474423, 1545998, 1688246],
        [1715152, 1674344, 1265083, 1816093, 1330216],
        [1517395, 1788509, 1018697, 1085967, 1700539],
        [1823260, 1701446, 1217793, 1091541, 1213386],
        [1102766, 1837942, 1311743, 1200064, 1665033]],

       [[1084486, 1420500,  951261, 1409876, 1539461],
        [1373414, 1918707, 1381903, 1492167, 1542554],
        [1492249, 1504673, 1118936,  948957, 1057805],
        [1343545, 1297526, 1340025, 1209363, 1930811],
        [1192370, 1592099, 1697326, 1791227, 1392562]],

       [[ 946625, 1071874, 1217317, 1253059, 1645214],
        [1771739, 1360594, 1693264, 1099393, 1625469],
        [1899062, 1234257, 1758411, 1808244, 1621284],
        [1111985, 1906562, 1442910, 1384659, 1205922],
        [1502421, 1596701, 1691348, 1688786, 1107790]],

       [[1040146, 1442220, 1813791, 1779269, 1844805],
        [1457408, 1579285, 1264223, 1140315, 1654840],
        [1540211, 1789707,  941945, 1336026, 1649883],
        [1529542, 1040760, 1635968,  967259, 1545622],
        [1766041, 1103719, 1340656, 1827259, 1759468]],

       [[1574276, 1095978, 1501457, 1319208, 1220988],
        [1906489, 1363057, 1846672, 1170888, 1079171],
        [1691723, 1587524, 1303479, 1487619, 1885149],
        [1015545, 1583913, 1426965, 1057042, 1862348],
        [1140924, 1308549, 1728018, 1672535, 1140901]],

       [[1333166, 1572589, 1762176, 1183624, 1529656],
        [1851593, 1815053, 1375248, 1726595, 1730404],
        [1316265, 1053595,  966590, 1046383, 1484121],
        [ 984608, 1199773, 1414266, 1654357, 1862733],
        [1703046, 1661303, 1500530, 1573033, 1037890]]])
```

In [20]:

```
a[numpy.r_[:len(a),0]]
```

Out[20]:

```
array([[[1333166, 1572589, 1762176, 1183624, 1529656],
        [1851593, 1815053, 1375248, 1726595, 1730404],
        [1316265, 1053595,  966590, 1046383, 1484121],
        [ 984608, 1199773, 1414266, 1654357, 1862733],
        [1703046, 1661303, 1500530, 1573033, 1037890]],

       [[1574276, 1095978, 1501457, 1319208, 1220988],
        [1906489, 1363057, 1846672, 1170888, 1079171],
        [1691723, 1587524, 1303479, 1487619, 1885149],
        [1015545, 1583913, 1426965, 1057042, 1862348],
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In [25]:

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a/b
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Out[25]:

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In [26]:

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a**3
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In [27]:

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(a > 0.5)
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Out[27]:

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```

In [28]:

```
numpy.nonzero(a > 0.5)
```

Out[28]:

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       3, 4, 4, 4, 4, 4, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3,
       3, 3, 3, 3, 4, 4, 4, 4, 4, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 2, 2, 2,
       2, 2, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1,
       2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 0, 0, 0, 0, 0, 1, 1,
       1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 0, 0, 0, 0,
       0, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 0,
       0, 0, 0, 0, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 4, 4, 4,
       4, 4, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3,
       4, 4, 4, 4, 4, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3,
       3, 3, 3, 4, 4, 4, 4, 4]),
 array([0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1,
       2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3,
       4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0,
       1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2,
       3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4,
       0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1,
       2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3,
       4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0,
       1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2,
       3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4,
       0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0, 1,
       2, 3, 4, 0, 1, 2, 3, 4]))
```

In [29]:

```
a[:, numpy.nonzero(v > 0.5)[0]]
```

Out[29]:

```
array([[[1333166, 1572589, 1762176, 1183624, 1529656],
        [1851593, 1815053, 1375248, 1726595, 1730404],
        [1316265, 1053595,  966590, 1046383, 1484121],
        [ 984608, 1199773, 1414266, 1654357, 1862733],
        [1703046, 1661303, 1500530, 1573033, 1037890]],

       [[1574276, 1095978, 1501457, 1319208, 1220988],
        [1906489, 1363057, 1846672, 1170888, 1079171],
        [1691723, 1587524, 1303479, 1487619, 1885149],
        [1015545, 1583913, 1426965, 1057042, 1862348],
        [1140924, 1308549, 1728018, 1672535, 1140901]],

       [[1040146, 1442220, 1813791, 1779269, 1844805],
        [1457408, 1579285, 1264223, 1140315, 1654840],
        [1540211, 1789707,  941945, 1336026, 1649883],
        [1529542, 1040760, 1635968,  967259, 1545622],
        [1766041, 1103719, 1340656, 1827259, 1759468]],

       [[ 946625, 1071874, 1217317, 1253059, 1645214],
        [1771739, 1360594, 1693264, 1099393, 1625469],
        [1899062, 1234257, 1758411, 1808244, 1621284],
        [1111985, 1906562, 1442910, 1384659, 1205922],
        [1502421, 1596701, 1691348, 1688786, 1107790]],

       [[1084486, 1420500,  951261, 1409876, 1539461],
        [1373414, 1918707, 1381903, 1492167, 1542554],
        [1492249, 1504673, 1118936,  948957, 1057805],
        [1343545, 1297526, 1340025, 1209363, 1930811],
        [1192370, 1592099, 1697326, 1791227, 1392562]],

       [[1381233, 1061264, 1474423, 1545998, 1688246],
        [1715152, 1674344, 1265083, 1816093, 1330216],
        [1517395, 1788509, 1018697, 1085967, 1700539],
        [1823260, 1701446, 1217793, 1091541, 1213386],
        [1102766, 1837942, 1311743, 1200064, 1665033]],
```

```
       [[1557863, 1537943,  957853,  974471, 1612175],
        [1021752, 1318286, 1784634, 1248913, 1788500],
        [1759678, 1432700,  967396, 1645855, 1249134],
        [1137195, 1667385, 1537180, 1065200, 1679509],
        [1274707,  964638, 1826730, 1772338, 1576104]],

       [[1893580, 1097519, 1589644, 1339521, 1254992],
        [1190201, 1086195, 1904122, 1688603, 1300525],
        [1252150, 1170372, 1239828, 1073623, 1008399],
        [1351539, 1298236, 1285932, 1483235, 1305192],
        [1374916, 1271813, 1884451, 1427769, 1858424]],

       [[1653711, 1598034, 1332210, 1806313,  988869],
        [1833353, 1804103, 1914530, 1635238, 1831884],
        [1781412, 1567835, 1576848, 1270079, 1226014],
        [1927021, 1573684, 1291355, 1679571, 1684789],
        [1529556, 1831723, 1119955, 1821060, 1093759]],

       [[1101804, 1508997, 1654952, 1552711, 1162481],
        [1563476, 1658582, 1241078, 1139909,  973681],
        [1488171,  975248, 1836697, 1561443, 1099087],
        [1099545,  936733, 1844351, 1278038, 1375810],
        [1744610, 1694214, 1009046, 1045958, 1623252]]])
```

In [30]:

```
a[:, v.T > 0.5]
```

Out[30]:

```
array([[[1333166, 1572589, 1762176, 1183624, 1529656],
        [1851593, 1815053, 1375248, 1726595, 1730404],
        [1316265, 1053595,  966590, 1046383, 1484121],
        [ 984608, 1199773, 1414266, 1654357, 1862733],
        [1703046, 1661303, 1500530, 1573033, 1037890]],

       [[1574276, 1095978, 1501457, 1319208, 1220988],
        [1906489, 1363057, 1846672, 1170888, 1079171],
        [1691723, 1587524, 1303479, 1487619, 1885149],
        [1015545, 1583913, 1426965, 1057042, 1862348],
        [1140924, 1308549, 1728018, 1672535, 1140901]],

       [[1040146, 1442220, 1813791, 1779269, 1844805],
        [1457408, 1579285, 1264223, 1140315, 1654840],
        [1540211, 1789707,  941945, 1336026, 1649883],
        [1529542, 1040760, 1635968,  967259, 1545622],
        [1766041, 1103719, 1340656, 1827259, 1759468]],

       [[ 946625, 1071874, 1217317, 1253059, 1645214],
        [1771739, 1360594, 1693264, 1099393, 1625469],
        [1899062, 1234257, 1758411, 1808244, 1621284],
        [1111985, 1906562, 1442910, 1384659, 1205922],
        [1502421, 1596701, 1691348, 1688786, 1107790]],

       [[1084486, 1420500,  951261, 1409876, 1539461],
        [1373414, 1918707, 1381903, 1492167, 1542554],
        [1492249, 1504673, 1118936,  948957, 1057805],
        [1343545, 1297526, 1340025, 1209363, 1930811],
        [1192370, 1592099, 1697326, 1791227, 1392562]],

       [[1381233, 1061264, 1474423, 1545998, 1688246],
        [1715152, 1674344, 1265083, 1816093, 1330216],
        [1517395, 1788509, 1018697, 1085967, 1700539],
        [1823260, 1701446, 1217793, 1091541, 1213386],
        [1102766, 1837942, 1311743, 1200064, 1665033]],

       [[1557863, 1537943,  957853,  974471, 1612175],
        [1021752, 1318286, 1784634, 1248913, 1788500],
        [1759678, 1432700,  967396, 1645855, 1249134],
        [1137195, 1667385, 1537180, 1065200, 1679509],
        [1274707,  964638, 1826730, 1772338, 1576104]],
```

```
       [[1893580, 1097519, 1589644, 1339521, 1254992],
        [1190201, 1086195, 1904122, 1688603, 1300525],
        [1252150, 1170372, 1239828, 1073623, 1008399],
        [1351539, 1298236, 1285932, 1483235, 1305192],
        [1374916, 1271813, 1884451, 1427769, 1858424]],

       [[1653711, 1598034, 1332210, 1806313,  988869],
        [1833353, 1804103, 1914530, 1635238, 1831884],
        [1781412, 1567835, 1576848, 1270079, 1226014],
        [1927021, 1573684, 1291355, 1679571, 1684789],
        [1529556, 1831723, 1119955, 1821060, 1093759]],

       [[1101804, 1508997, 1654952, 1552711, 1162481],
        [1563476, 1658582, 1241078, 1139909,  973681],
        [1488171,  975248, 1836697, 1561443, 1099087],
        [1099545,  936733, 1844351, 1278038, 1375810],
        [1744610, 1694214, 1009046, 1045958, 1623252]]])
```

In [31]:

```
a[a < 0.5]=0
a
```

Out[31]:

```
array([[[1333166, 1572589, 1762176, 1183624, 1529656],
        [1851593, 1815053, 1375248, 1726595, 1730404],
        [1316265, 1053595,  966590, 1046383, 1484121],
        [ 984608, 1199773, 1414266, 1654357, 1862733],
        [1703046, 1661303, 1500530, 1573033, 1037890]],

       [[1574276, 1095978, 1501457, 1319208, 1220988],
        [1906489, 1363057, 1846672, 1170888, 1079171],
        [1691723, 1587524, 1303479, 1487619, 1885149],
        [1015545, 1583913, 1426965, 1057042, 1862348],
        [1140924, 1308549, 1728018, 1672535, 1140901]],

       [[1040146, 1442220, 1813791, 1779269, 1844805],
        [1457408, 1579285, 1264223, 1140315, 1654840],
        [1540211, 1789707,  941945, 1336026, 1649883],
        [1529542, 1040760, 1635968,  967259, 1545622],
        [1766041, 1103719, 1340656, 1827259, 1759468]],

       [[ 946625, 1071874, 1217317, 1253059, 1645214],
        [1771739, 1360594, 1693264, 1099393, 1625469],
        [1899062, 1234257, 1758411, 1808244, 1621284],
        [1111985, 1906562, 1442910, 1384659, 1205922],
        [1502421, 1596701, 1691348, 1688786, 1107790]],

       [[1084486, 1420500,  951261, 1409876, 1539461],
        [1373414, 1918707, 1381903, 1492167, 1542554],
        [1492249, 1504673, 1118936,  948957, 1057805],
        [1343545, 1297526, 1340025, 1209363, 1930811],
        [1192370, 1592099, 1697326, 1791227, 1392562]],

       [[1381233, 1061264, 1474423, 1545998, 1688246],
        [1715152, 1674344, 1265083, 1816093, 1330216],
        [1517395, 1788509, 1018697, 1085967, 1700539],
        [1823260, 1701446, 1217793, 1091541, 1213386],
        [1102766, 1837942, 1311743, 1200064, 1665033]],

       [[1557863, 1537943,  957853,  974471, 1612175],
        [1021752, 1318286, 1784634, 1248913, 1788500],
        [1759678, 1432700,  967396, 1645855, 1249134],
        [1137195, 1667385, 1537180, 1065200, 1679509],
        [1274707,  964638, 1826730, 1772338, 1576104]],

       [[1893580, 1097519, 1589644, 1339521, 1254992],
        [1190201, 1086195, 1904122, 1688603, 1300525],
        [1252150, 1170372, 1239828, 1073623, 1008399],
        [1351539, 1298236, 1285932, 1483235, 1305192],
        [1374916, 1271813, 1884451, 1427769, 1858424]],
```

```
       [[1653711, 1598034, 1332210, 1806313,  988869],
        [1833353, 1804103, 1914530, 1635238, 1831884],
        [1781412, 1567835, 1576848, 1270079, 1226014],
        [1927021, 1573684, 1291355, 1679571, 1684789],
        [1529556, 1831723, 1119955, 1821060, 1093759]],

       [[1101804, 1508997, 1654952, 1552711, 1162481],
        [1563476, 1658582, 1241078, 1139909,  973681],
        [1488171,  975248, 1836697, 1561443, 1099087],
        [1099545,  936733, 1844351, 1278038, 1375810],
        [1744610, 1694214, 1009046, 1045958, 1623252]]])
```

In [32]:

```
a * (a > 0.5)
a
```

Out[32]:

```
array([[[1333166, 1572589, 1762176, 1183624, 1529656],
        [1851593, 1815053, 1375248, 1726595, 1730404],
        [1316265, 1053595,  966590, 1046383, 1484121],
        [ 984608, 1199773, 1414266, 1654357, 1862733],
        [1703046, 1661303, 1500530, 1573033, 1037890]],

       [[1574276, 1095978, 1501457, 1319208, 1220988],
        [1906489, 1363057, 1846672, 1170888, 1079171],
        [1691723, 1587524, 1303479, 1487619, 1885149],
        [1015545, 1583913, 1426965, 1057042, 1862348],
        [1140924, 1308549, 1728018, 1672535, 1140901]],

       [[1040146, 1442220, 1813791, 1779269, 1844805],
        [1457408, 1579285, 1264223, 1140315, 1654840],
        [1540211, 1789707,  941945, 1336026, 1649883],
        [1529542, 1040760, 1635968,  967259, 1545622],
        [1766041, 1103719, 1340656, 1827259, 1759468]],

       [[ 946625, 1071874, 1217317, 1253059, 1645214],
        [1771739, 1360594, 1693264, 1099393, 1625469],
        [1899062, 1234257, 1758411, 1808244, 1621284],
        [1111985, 1906562, 1442910, 1384659, 1205922],
        [1502421, 1596701, 1691348, 1688786, 1107790]],

       [[1084486, 1420500,  951261, 1409876, 1539461],
        [1373414, 1918707, 1381903, 1492167, 1542554],
        [1492249, 1504673, 1118936,  948957, 1057805],
        [1343545, 1297526, 1340025, 1209363, 1930811],
        [1192370, 1592099, 1697326, 1791227, 1392562]],

       [[1381233, 1061264, 1474423, 1545998, 1688246],
        [1715152, 1674344, 1265083, 1816093, 1330216],
        [1517395, 1788509, 1018697, 1085967, 1700539],
        [1823260, 1701446, 1217793, 1091541, 1213386],
        [1102766, 1837942, 1311743, 1200064, 1665033]],

       [[1557863, 1537943,  957853,  974471, 1612175],
        [1021752, 1318286, 1784634, 1248913, 1788500],
        [1759678, 1432700,  967396, 1645855, 1249134],
        [1137195, 1667385, 1537180, 1065200, 1679509],
        [1274707,  964638, 1826730, 1772338, 1576104]],

       [[1893580, 1097519, 1589644, 1339521, 1254992],
        [1190201, 1086195, 1904122, 1688603, 1300525],
        [1252150, 1170372, 1239828, 1073623, 1008399],
        [1351539, 1298236, 1285932, 1483235, 1305192],
        [1374916, 1271813, 1884451, 1427769, 1858424]],

       [[1653711, 1598034, 1332210, 1806313,  988869],
        [1833353, 1804103, 1914530, 1635238, 1831884],
        [1781412, 1567835, 1576848, 1270079, 1226014],
        [1927021, 1573684, 1291355, 1679571, 1684789],
        [1529556, 1831723, 1119955, 1821060, 1093759]],
```

```
       [[1101804, 1508997, 1654952, 1552711, 1162481],
        [1563476, 1658582, 1241078, 1139909,  973681],
        [1488171,  975248, 1836697, 1561443, 1099087],
        [1099545,  936733, 1844351, 1278038, 1375810],
        [1744610, 1694214, 1009046, 1045958, 1623252]]])
```

In [33]:

```
a[:] = 3; a
```

Out[33]:

```
array([[[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]]])
```

In [34]:

```
x = a.copy()
x
```

Out[34]:

```
array([[[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]]])
```

In [35]:

```
y = x[1, :].copy()
y
```

Out[35]:

```
array([[3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3]])
```

In [36]:

```
y = x.flatten()
y
```

Out[36]:

```
array([3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
       3, 3, 3, 3, 3, 3, 3, 3])
```

In [37]:

```
numpy.arange(1., 11.), numpy.r_[1.:11.], numpy.r_[1:10:10j]
```

Out[37]:

```
(array([ 1.,  2.,  3.,  4.,  5.,  6.,  7.,  8.,  9., 10.]),
 array([ 1.,  2.,  3.,  4.,  5.,  6.,  7.,  8.,  9., 10.]),
 array([ 1.,  2.,  3.,  4.,  5.,  6.,  7.,  8.,  9., 10.]))
```

In [38]:

```
numpy.arange(10.), numpy.r_[:10.], numpy.r_[:9:10j]
```

Out[38]:

```
(array([0., 1., 2., 3., 4., 5., 6., 7., 8., 9.]),
 array([0., 1., 2., 3., 4., 5., 6., 7., 8., 9.]),
 array([0., 1., 2., 3., 4., 5., 6., 7., 8., 9.]))
```

In [39]:

```
numpy.arange(1.,11.)[:, numpy.newaxis]
```

Out[39]:

```
array([[ 1.],
       [ 2.],
       [ 3.],
       [ 4.],
       [ 5.],
       [ 6.],
       [ 7.],
       [ 8.],
       [ 9.],
       [10.]])
```

In [40]:

```
numpy.zeros((3, 4))
```

Out[40]:

```
array([[0., 0., 0., 0.],
       [0., 0., 0., 0.],
       [0., 0., 0., 0.]])
```

```
       [0., 0., 0., 0.]])
```

In [41]:

```
numpy.zeros((3, 4, 5))
```

Out[41]:

```
array([[[0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.]],

       [[0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.]],

       [[0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.]]])
```

In [42]:

```
numpy.ones((3, 4))
```

Out[42]:

```
array([[1., 1., 1., 1.],
       [1., 1., 1., 1.],
       [1., 1., 1., 1.]])
```

In [43]:

```
numpy.eye(3)
```

Out[43]:

```
array([[1., 0., 0.],
       [0., 1., 0.],
       [0., 0., 1.]])
```

In [44]:

```
numpy.diag(b)
```

Out[44]:

```
array([1071923,  556470, 1117176,  532941, 1369078])
```

In [45]:

```
numpy.diag(v, 0)
```

Out[45]:

```
array([[634179,      0,      0,      0,      0],
       [     0, 497420,      0,      0,      0],
       [     0,      0, 175388,      0,      0],
       [     0,      0,      0, 158783,      0],
       [     0,      0,      0,      0, 489084]])
```

In [46]:

```
from numpy.random import default_rng; rng = default_rng(42); rng.random((3, 4))
```

Out[46]:

```
array([[0.77395605, 0.43887844, 0.85859792, 0.69736803],
       [0.09417735, 0.97562235, 0.7611397 , 0.78606431],
       [0.12811363, 0.45038594, 0.37079802, 0.92676499]])
```

In [47]:

```
numpy.linspace(1,3,4)
```

Out[47]:

```
array([1.        , 1.66666667, 2.33333333, 3.        ])
```

In [48]:

```
numpy.mgrid[0:9.,0:6.], numpy.meshgrid(numpy.r_[0:9.],numpy.r_[0:6.])
```

Out[48]:

```
(array([[[0., 0., 0., 0., 0., 0.],
         [1., 1., 1., 1., 1., 1.],
         [2., 2., 2., 2., 2., 2.],
         [3., 3., 3., 3., 3., 3.],
         [4., 4., 4., 4., 4., 4.],
         [5., 5., 5., 5., 5., 5.],
         [6., 6., 6., 6., 6., 6.],
         [7., 7., 7., 7., 7., 7.],
         [8., 8., 8., 8., 8., 8.]],

        [[0., 1., 2., 3., 4., 5.],
         [0., 1., 2., 3., 4., 5.],
         [0., 1., 2., 3., 4., 5.],
         [0., 1., 2., 3., 4., 5.],
         [0., 1., 2., 3., 4., 5.],
         [0., 1., 2., 3., 4., 5.],
         [0., 1., 2., 3., 4., 5.],
         [0., 1., 2., 3., 4., 5.],
         [0., 1., 2., 3., 4., 5.]]]),
 [array([[0., 1., 2., 3., 4., 5., 6., 7., 8.],
         [0., 1., 2., 3., 4., 5., 6., 7., 8.],
         [0., 1., 2., 3., 4., 5., 6., 7., 8.],
         [0., 1., 2., 3., 4., 5., 6., 7., 8.],
         [0., 1., 2., 3., 4., 5., 6., 7., 8.],
         [0., 1., 2., 3., 4., 5., 6., 7., 8.]]),
  array([[0., 0., 0., 0., 0., 0., 0., 0., 0.],
         [1., 1., 1., 1., 1., 1., 1., 1., 1.],
         [2., 2., 2., 2., 2., 2., 2., 2., 2.],
         [3., 3., 3., 3., 3., 3., 3., 3., 3.],
         [4., 4., 4., 4., 4., 4., 4., 4., 4.],
         [5., 5., 5., 5., 5., 5., 5., 5., 5.]])])
```

In [49]:

```
numpy.ogrid[0:9.,0:6.], numpy.ix_(numpy.r_[0:9.],numpy.r_[0:6.])
```

Out[49]:

```
([array([[0.],
         [1.],
         [2.],
         [3.],
         [4.],
         [5.],
         [6.],
         [7.],
         [8.]]),
  array([[0., 1., 2., 3., 4., 5.]])],
 (array([[0.],
         [1.],
         [2.],
         [3.],
         [4.],
         [5.],
         [6.],
         [7.],
         [8.]]),
  array([[0., 1., 2., 3., 4., 5.]])))
```

In [50]:

```
numpy.meshgrid([1,2,4],[2,4,5])
```

Out[50]:

```
[array([[1, 2, 4],
        [1, 2, 4],
        [1, 2, 4]]),
 array([[2, 2, 2],
        [4, 4, 4],
        [5, 5, 5]])]
```

In [51]:

```
numpy.ix_([1,2,4],[2,4,5])
```

Out[51]:

```
(array([[1],
        [2],
        [4]]),
 array([[2, 4, 5]]))
```

In [52]:

```
m, n = 3, 2; numpy.tile(a, (m, n))
```

Out[52]:

```
array([[[3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        ...,
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3]],

       [[3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        ...,
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3]],

       [[3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        ...,
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3]],

       ...,

       [[3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        ...,
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3]],

       [[3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        ...,
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3]],

       [[3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3]
```

```
        [3, 3, 3, ..., 3, 3, 3],
        ...,
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3],
        [3, 3, 3, ..., 3, 3, 3]]])
```

In [53]:

```
numpy.concatenate((a,c), 1), numpy.hstack((a,c)), numpy.column_stack((a,c)), numpy.c_[a, c]
```

Out[53]:

```
(array([[[     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [492324, 323958, 170951, 631241, 546227],
         [852417, 276175, 266483, 713633, 818380],
         [455644, 281691, 299624, 413874, 542590],
         [427224,  13698, 131400,   4712, 493744],
         [935225, 584055, 578213,  63383, 119415]],

        [[     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [897882, 647001, 576857, 125888, 123788],
         [713564, 691293,   6961,   6418, 263168],
         [441504, 405296, 373869,  40807, 170377],
         [531884, 290690, 986347, 183356, 643225],
         [663582, 759594, 716910, 853372, 304256]],

        [[     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [557934, 136752, 848289, 286605, 778586],
         [956882, 156230, 534127, 727552, 204196],
         [774810, 901355, 973309, 481180, 919568],
         [215595, 168581, 697081, 817427, 742976],
         [794070, 258597, 695581, 466472, 137188]],

        [[     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [817702, 541483,  71978, 176111, 278004],
         [920101, 132915, 467893, 637930, 491594],
         [627337, 660080, 691326, 395002, 858052],
         [217616, 401202, 293274, 683439, 140350],
         [652231, 288444,  52748, 631052, 547000]],

        [[     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [348503, 903376, 542814, 286976, 807991],
         [681765, 912001, 445221,  86581, 411999],
         [366178, 147770, 957430, 397043, 686284],
         [544099, 757609, 318846, 961863, 184143],
         [561251, 692413, 979474, 587359, 444997]],

        [[     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
         [     3,      3,      3,      3,      3],
```

```
        [353583, 345423, 938805, 414864, 456574],
        [ 91978, 134605, 750254, 778138, 729034],
        [554342, 803264, 667889, 886997,  71753],
        [181168, 483377, 590493, 911285, 686321],
        [681170, 342574, 724881, 857389,  33283]],

       [[     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [279948, 555581,  95444, 707054,  37354],
        [450443, 810355, 936269, 353678, 448164],
        [386147, 384141, 770001, 761841, 225401],
        [800753, 672643, 740626, 426435, 941785],
        [ 61538, 260571, 350224, 817528, 422037]],

       [[     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [574946, 980999, 588364, 140499,   8566],
        [612150, 972297, 132625, 792481, 104368],
        [481187, 237429, 381262, 805704, 979303],
        [  3936, 612100, 374208, 834273, 760718],
        [159485, 244334, 167133, 592823,  95776]],

       [[     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [559463, 303879, 700328, 332840, 726956],
        [214252, 293377, 419598, 955411, 464181],
        [822602, 182499, 210935, 103325, 863497],
        [816301, 166462, 174765, 164192, 885551],
        [117042, 690611, 307745, 170195, 156251]],

       [[     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
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        [663796, 761127, 639199, 699540, 835212],
        [172505, 538434, 321707, 696562, 979762],
        [651319, 742859, 252629, 811798, 699286],
        [530832, 806405, 390688, 291558, 321632]]]),
array([[[     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [492324, 323958, 170951, 631241, 546227],
        [852417, 276175, 266483, 713633, 818380],
        [455644, 281691, 299624, 413874, 542590],
        [427224,  13698, 131400,   4712, 493744],
        [935225, 584055, 578213,  63383, 119415]],

       [[     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [897882, 647001, 576857, 125888, 123788],
        [713564, 691293,   6961,   6418, 263168],
        [441504, 405296, 373869,  40807, 170377],
        [531884, 290690, 986347, 183356, 643225],
        [663582, 759594, 716910, 853372, 304256]],

       [[     3,      3,      3,      3,      3],
```

```
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 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [557934, 136752, 848289, 286605, 778586],
 [956882, 156230, 534127, 727552, 204196],
 [774810, 901355, 973309, 481180, 919568],
 [215595, 168581, 697081, 817427, 742976],
 [794070, 258597, 695581, 466472, 137188]],

[[     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [817702, 541483,  71978, 176111, 278004],
 [920101, 132915, 467893, 637930, 491594],
 [627337, 660080, 691326, 395002, 858052],
 [217616, 401202, 293274, 683439, 140350],
 [652231, 288444,  52748, 631052, 547000]],

[[     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [348503, 903376, 542814, 286976, 807991],
 [681765, 912001, 445221,  86581, 411999],
 [366178, 147770, 957430, 397043, 686284],
 [544099, 757609, 318846, 961863, 184143],
 [561251, 692413, 979474, 587359, 444997]],

[[     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [353583, 345423, 938805, 414864, 456574],
 [ 91978, 134605, 750254, 778138, 729034],
 [554342, 803264, 667889, 886997,  71753],
 [181168, 483377, 590493, 911285, 686321],
 [681170, 342574, 724881, 857389,  33283]],

[[     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [279948, 555581,  95444, 707054,  37354],
 [450443, 810355, 936269, 353678, 448164],
 [386147, 384141, 770001, 761841, 225401],
 [800753, 672643, 740626, 426435, 941785],
 [ 61538, 260571, 350224, 817528, 422037]],

[[     3,      3,      3,      3,      3],
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 [574946, 980999, 588364, 140499,   8566],
 [612150, 972297, 132625, 792481, 104368],
 [481187, 237429, 381262, 805704, 979303],
 [  3936, 612100, 374208, 834273, 760718],
 [159485, 244334, 167133, 592823,  95776]],

[[     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [     3,      3,      3,      3,      3],
 [559463, 303879, 700328, 332840, 726956],
 [214252, 293377, 419598, 955411, 464181],
```

```
          [822602, 182499, 210935, 103325, 863497],
          [816301, 166462, 174765, 164192, 885551],
          [117042, 690611, 307745, 170195, 156251]],

         [[     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [603431, 881595, 461224, 149395, 431520],
          [663796, 761127, 639199, 699540, 835212],
          [172505, 538434, 321707, 696562, 979762],
          [651319, 742859, 252629, 811798, 699286],
          [530832, 806405, 390688, 291558, 321632]]]),
 array([[[     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [492324, 323958, 170951, 631241, 546227],
          [852417, 276175, 266483, 713633, 818380],
          [455644, 281691, 299624, 413874, 542590],
          [427224,  13698, 131400,   4712, 493744],
          [935225, 584055, 578213,  63383, 119415]],

         [[     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [897882, 647001, 576857, 125888, 123788],
          [713564, 691293,   6961,   6418, 263168],
          [441504, 405296, 373869,  40807, 170377],
          [531884, 290690, 986347, 183356, 643225],
          [663582, 759594, 716910, 853372, 304256]],

         [[     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [557934, 136752, 848289, 286605, 778586],
          [956882, 156230, 534127, 727552, 204196],
          [774810, 901355, 973309, 481180, 919568],
          [215595, 168581, 697081, 817427, 742976],
          [794070, 258597, 695581, 466472, 137188]],

         [[     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [817702, 541483,  71978, 176111, 278004],
          [920101, 132915, 467893, 637930, 491594],
          [627337, 660080, 691326, 395002, 858052],
          [217616, 401202, 293274, 683439, 140350],
          [652231, 288444,  52748, 631052, 547000]],

         [[     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
          [     3,      3,      3,      3,      3],
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In [54]:

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        [     3,      3,      3,      3,      3]],

       [[     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3],
        [     3,      3,      3,      3,      3]],

       [[492324, 323958, 170951, 631241, 546227],
        [852417, 276175, 266483, 713633, 818380],
        [455644, 281691, 299624, 413874, 542590],
        [427224,  13698, 131400,   4712, 493744],
        [935225, 584055, 578213,  63383, 119415]],

       [[897882, 647001, 576857, 125888, 123788],
        [713564, 691293,   6961,   6418, 263168],
        [441504, 405296, 373869,  40807, 170377],
        [531884, 290690, 986347, 183356, 643225],
        [663582, 759594, 716910, 853372, 304256]],

       [[557934, 136752, 848289, 286605, 778586],
        [956882, 156230, 534127, 727552, 204196],
        [774810, 901355, 973309, 481180, 919568],
        [215595, 168581, 697081, 817427, 742976],
        [794070, 258597, 695581, 466472, 137188]],

       [[817702, 541483,  71978, 176111, 278004],
        [920101, 132915, 467893, 637930, 491594],
        [627337, 660080, 691326, 395002, 858052],
        [217616, 401202, 293274, 683439, 140350],
        [652231, 288444,  52748, 631052, 547000]],

       [[348503, 903376, 542814, 286976, 807991],
        [681765, 912001, 445221,  86581, 411999],
        [366178, 147770, 957430, 397043, 686284],
        [544099, 757609, 318846, 961863, 184143],
        [561251, 692413, 979474, 587359, 444997]],

       [[353583, 345423, 938805, 414864, 456574],
        [ 91978, 134605, 750254, 778138, 729034],
        [554342, 803264, 667889, 886997,  71753],
        [181168, 483377, 590493, 911285, 686321],
        [681170, 342574, 724881, 857389,  33283]],

       [[279948, 555581,  95444, 707054,  37354],
        [450443, 810355, 936269, 353678, 448164],
        [386147, 384141, 770001, 761841, 225401],
```

```
         [800753, 672643, 740626, 426435, 941785],
         [ 61538, 260571, 350224, 817528, 422037]],

        [[574946, 980999, 588364, 140499,   8566],
         [612150, 972297, 132625, 792481, 104368],
         [481187, 237429, 381262, 805704, 979303],
         [  3936, 612100, 374208, 834273, 760718],
         [159485, 244334, 167133, 592823,  95776]],

        [[559463, 303879, 700328, 332840, 726956],
         [214252, 293377, 419598, 955411, 464181],
         [822602, 182499, 210935, 103325, 863497],
         [816301, 166462, 174765, 164192, 885551],
         [117042, 690611, 307745, 170195, 156251]],

        [[603431, 881595, 461224, 149395, 431520],
         [663796, 761127, 639199, 699540, 835212],
         [172505, 538434, 321707, 696562, 979762],
         [651319, 742859, 252629, 811798, 699286],
         [530832, 806405, 390688, 291558, 321632]]]))
```

In [55]:

```
numpy.nanmax(a)
```

Out[55]:

```
3
```

In [56]:

```
a.max(0)
```

Out[56]:

```
array([[3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3]])
```

In [57]:

```
a.max(1)
```

Out[57]:

```
array([[3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3],
       [3, 3, 3, 3, 3]])
```

In [58]:

```
numpy.maximum(a, b)
```

Out[58]:

```
array([[[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]],

       [[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851]
```

```
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]],

       [[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]],

       [[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]],

       [[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]],

       [[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]],

       [[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]],

       [[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]],

       [[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]],

       [[1071923, 1174951,  769171, 1008934, 1007839],
        [1306766,  556470, 1292268, 1216310,  419191],
        [1153759,  888760, 1117176,  421495, 1220655],
        [1003158,  579495,  747594,  532941,  436851],
        [ 592716,  641195, 1214565,  645150, 1369078]]])
```

In [59]:

```
numpy.sqrt(v @ v), numpy.linalg.norm(v)
```

Out[59]:

```
(972000.931650788, 972000.931650788)
```

In [60]:

```
numpy.logical_and(a, b)
```

Out[60]:

```
array([[[ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True]],

       [[ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
```

```
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]]])
```

In [61]:

```
numpy.logical_or(a, b)
```

Out[61]:

```
array([[[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]],

        [[ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True],
         [ True,  True,  True,  True,  True]
```

```
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True]],

       [[ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True]],

       [[ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True]],

       [[ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True]],

       [[ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True]],

       [[ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True]],

       [[ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True]],

       [[ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True],
        [ True,  True,  True,  True,  True]]])
```

In [62]:

```
a & b
```

Out[62]:

```
array([[[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]],

       [[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]],

       [[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]],

       [[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
```

```
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]],

       [[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]],

       [[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]],

       [[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]],

       [[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]],

       [[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]],

       [[3, 3, 3, 2, 3],
        [2, 2, 0, 2, 3],
        [3, 0, 0, 3, 3],
        [2, 3, 2, 1, 3],
        [0, 3, 1, 2, 2]]])
```

In [63]:

```
a | b
```

Out[63]:

```
array([[[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]],

       [[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]],

       [[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]],

       [[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]],

       [[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
```

```
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]],

       [[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]],

       [[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]],

       [[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]],

       [[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]],

       [[1071923, 1174951,  769171, 1008935, 1007839],
        [1306767,  556471, 1292271, 1216311,  419191],
        [1153759,  888763, 1117179,  421495, 1220655],
        [1003159,  579495,  747595,  532943,  436851],
        [ 592719,  641195, 1214567,  645151, 1369079]]])
```

In [64]:

```
numpy.linalg.inv(c)
```

Out[64]:

```
array([[[-3.60373941e-07,  2.19363644e-06, -3.35434917e-06,
          2.61659933e-07,  7.74283640e-07],
        [ 9.50445900e-06, -6.95865902e-06, -2.68371794e-06,
          3.74172723e-06,  9.37389694e-07],
        [-9.24481949e-06,  3.68998757e-06,  7.83258586e-06,
         -4.42575199e-06, -2.90887123e-07],
        [-2.70180000e-06,  3.21274696e-06,  1.10920879e-06,
         -3.44022960e-06, -4.74853458e-07],
        [ 2.53424544e-06, -2.71771860e-06,  8.81816615e-07,
          2.90578233e-06, -6.14028404e-07]],

       [[ 3.79556139e-06,  1.15321989e-06, -8.03539375e-06,
          1.12796884e-06, -4.26703171e-07],
        [-3.37056964e-06, -4.41143354e-07,  9.03016973e-06,
         -1.77573647e-06,  4.50264748e-07],
        [-2.52471891e-07, -1.77075000e-06,  3.71416329e-06,
         -1.67683476e-07, -9.10156825e-08],
        [ 7.77772346e-07,  3.16477484e-07, -4.22222330e-06,
          2.72515974e-07,  1.19805369e-06],
        [-1.44986874e-06,  1.87088913e-06, -1.92835557e-06,
          1.60389741e-06, -5.25914826e-08]],

       [[ 7.33768211e-07,  1.82811857e-06,  1.76363166e-07,
         -1.25116732e-06, -1.29156184e-06],
        [-1.47562749e-06, -4.95178697e-07,  1.32292242e-06,
         -1.91477828e-08,  3.47884921e-07],
        [ 2.66297895e-07, -2.55217259e-06, -6.91584853e-07,
          6.53146509e-07,  3.38582632e-06],
        [-1.16863923e-06,  5.72048608e-07, -1.32824280e-07,
          1.24602978e-06, -7.69247872e-08],
        [ 1.15779252e-06,  1.34702540e-06,  4.43651226e-07,
         -2.70346599e-07, -2.79619706e-06]],

       [[ 9.90166673e-07,  9.86631803e-07, -5.37825164e-07,
```

```
[[ 9.90166675e-07,  9.86651805e-07, -5.37825164e-07,
  -4.72871755e-07, -4.24941611e-07],
 [ 1.12638682e-06, -1.31530316e-06,  3.93314329e-07,
   9.39537860e-07, -2.48433607e-07],
 [-3.44007983e-07,  1.18349231e-06,  6.35479464e-07,
   4.68838026e-07, -2.00591950e-06],
 [-6.17584003e-07,  9.52860314e-08, -5.35785435e-07,
   1.12211132e-06,  7.80790167e-07],
 [-1.02896447e-06, -7.06906463e-07,  9.90722643e-07,
  -1.27134059e-06,  1.75851613e-06]],

[[-1.89781603e-06,  2.54455607e-06,  1.96698222e-06,
   9.52775236e-07, -2.33774970e-06],
 [ 1.06106830e-06, -4.82729062e-07, -1.89016357e-06,
  -4.94306759e-07,  1.63992656e-06],
 [-1.52388456e-07, -6.93226943e-07, -7.15038799e-07,
  -1.11233231e-06,  2.48155651e-06],
 [ 1.09631446e-07, -8.70959198e-07,  2.99377294e-07,
   1.16798241e-06, -3.37711343e-07],
 [ 9.33312296e-07,  2.17252548e-07,  1.63893926e-06,
   4.74146946e-07, -2.37238544e-06]],

[[ 2.01379006e-06, -6.18881907e-06, -4.71202669e-06,
   5.55155218e-06,  3.61657730e-06],
 [ 5.78562254e-07, -1.09122408e-06,  1.38146457e-06,
   7.00797549e-07, -1.46360981e-06],
 [ 2.18036916e-07,  3.56371524e-06,  2.40491283e-06,
  -4.11126927e-06, -1.45806671e-06],
 [-2.07881648e-06,  2.49421977e-06,  1.29490643e-06,
  -1.40490954e-06,  6.21349335e-08],
 [ 1.63356067e-06, -3.97569849e-06, -3.51761456e-06,
   4.90067430e-06,  1.24813723e-06]],

[[ 7.02007469e-07, -1.67842235e-06,  1.63977148e-06,
   1.31792557e-06, -2.09655311e-06],
 [ 1.12979272e-06,  1.62525288e-06, -1.73258509e-06,
  -4.88247495e-07,  1.89008246e-07],
 [-1.14588512e-06,  7.31361668e-07,  1.09654729e-06,
  -5.34323719e-07, -6.85043464e-08],
 [ 4.40385419e-07, -7.11964789e-07,  6.33130924e-07,
  -1.06092769e-07,  6.15668924e-07],
 [-7.02076584e-07,  1.35147596e-08, -1.30577713e-06,
   7.58197583e-07,  1.42270204e-06]],

[[ 1.67991682e-07,  6.00661291e-07,  1.19945498e-06,
  -1.60066441e-06, -2.20352269e-07],
 [ 9.44205120e-08,  8.94973590e-07, -7.09477834e-07,
   9.98437396e-07, -1.65961136e-06],
 [ 1.49099683e-06, -2.08594606e-06,  3.78648226e-08,
  -9.65649538e-08,  2.51954251e-06],
 [-4.53992155e-07,  1.05653095e-08, -1.56977206e-07,
  -5.50069363e-08,  2.07107450e-06],
 [-3.12396387e-07,  2.91285093e-07,  7.18193670e-07,
   6.27279576e-07, -2.17420790e-06]],

[[-5.83775683e-06,  4.94777101e-06,  5.13325652e-05,
  -4.75672983e-05, -1.63273496e-06],
 [-4.38797339e-07, -4.14662915e-07, -3.27213480e-06,
   3.44136213e-06,  1.85241643e-06],
 [ 1.43313867e-06,  2.66928213e-07,  7.41473424e-06,
  -8.42790204e-06, -6.71966560e-07],
 [-1.87121242e-06,  2.36374654e-06,  1.05926433e-05,
  -9.92820048e-06, -5.86908432e-07],
 [ 5.52784136e-06, -4.97385558e-06, -5.01305984e-05,
   4.78339593e-05,  1.39827988e-06]],

[[ 3.16546148e-06,  9.88728764e-07, -2.20284542e-06,
   2.24971785e-06, -4.99542966e-06],
 [-7.79404919e-07, -2.13373459e-06,  1.25351246e-06,
  -3.99865791e-07,  3.63746834e-06],
 [-2.60970482e-06,  2.94535329e-06, -2.60352238e-07,
  -2.87390375e-06,  2.89433048e-06],
 [-4.23484778e-06,  5.56318268e-07,  2.01371366e-08,
```

```
         6.74773590e-08,  4.02902151e-06],
       [ 3.73865747e-06, -3.64105099e-07,  7.90802759e-07,
         7.19324234e-07, -4.93424902e-06]]])
```

In [65]:

```
numpy.linalg.pinv(a)
```

Out[65]:

```
array([[[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]],

       [[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]],

       [[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]],

       [[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]],

       [[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]],

       [[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]],

       [[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]],

       [[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]],

       [[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]],

       [[0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333],
        [0.01333333, 0.01333333, 0.01333333, 0.01333333, 0.01333333]]])
```

In [66]:

```
numpy.linalg.matrix_rank(a)
```

Out[66]:

```
array([1, 1, 1, 1, 1, 1, 1, 1, 1, 1])
```

In [67]:

```
numpy.linalg.solve(c[0], b),  numpy.linalg.lstsq(c[0], b)
```

```
/var/folders/7k/wfdc1r714qgglwzkz4_kmf3rybjsnh/T/ipykernel_26882/3494675964.py:1: FutureW
arning: `rcond` parameter will change to the default of machine precision times ``max(M,
N)`` where M and N are the input matrix dimensions.
To use the future default and silence this warning we advise to pass `rcond=None`, to kee
p using the old, explicitly pass `rcond=-1`.
  numpy.linalg.solve(c[0], b),  numpy.linalg.lstsq(c[0], b)
```

Out[67]:

```
(array([[-0.66841759, -1.5358428 , -0.05378819,  1.52968541, -2.36378824],
        [ 2.30749494,  7.67916927, -0.74426987,  2.5931884 ,  6.30400039],
        [-0.66300988, -4.59877003,  2.7460158 , -4.08417866, -0.5412363 ],
        [-1.15060052, -2.69893442,  0.16412993, -0.49050677, -2.17524271],
        [ 2.73351189,  3.53918306,  0.8489597 ,  0.77544948,  2.92000321]]),
 (array([[-0.66841759, -1.5358428 , -0.05378819,  1.52968541, -2.36378824],
         [ 2.30749494,  7.67916927, -0.74426987,  2.5931884 ,  6.30400039],
         [-0.66300988, -4.59877003,  2.7460158 , -4.08417866, -0.5412363 ],
         [-1.15060052, -2.69893442,  0.16412993, -0.49050677, -2.17524271],
         [ 2.73351189,  3.53918306,  0.8489597 ,  0.77544948,  2.92000321]]),
  array([], dtype=float64),
  5,
  array([2269485.39914583,  806241.31591737,  393013.39925138,
          151874.55486185,   52663.46144239])))
```

In [68]:

```
numpy.linalg.solve(c[0].T, b.T),  numpy.linalg.lstsq(c[0].T, b.T)
```

```
/var/folders/7k/wfdc1r714qgglwzkz4_kmf3rybjsnh/T/ipykernel_26882/1937338015.py:1: FutureW
arning: `rcond` parameter will change to the default of machine precision times ``max(M,
N)`` where M and N are the input matrix dimensions.
To use the future default and silence this warning we advise to pass `rcond=None`, to kee
p using the old, explicitly pass `rcond=-1`.
  numpy.linalg.solve(c[0].T, b.T),  numpy.linalg.lstsq(c[0].T, b.T)
```

Out[68]:

```
(array([[ 3.49830694, -9.35265598, -0.34204798, -2.09790946, -3.62130859],
        [-2.48401575,  6.53119047, -1.49452447,  1.45163489, -0.32798925],
        [ 1.28360444,  5.96383343,  4.03900507,  1.91181618,  7.72710348],
        [ 0.73026152, -6.26147828,  0.77996425, -1.44191264, -1.06231811],
        [ 0.60967989,  0.32256847,  0.45181387,  0.5811682 , -0.44032592]]),
 (array([[ 3.49830694, -9.35265598, -0.34204798, -2.09790946, -3.62130859],
         [-2.48401575,  6.53119047, -1.49452447,  1.45163489, -0.32798925],
         [ 1.28360444,  5.96383343,  4.03900507,  1.91181618,  7.72710348],
         [ 0.73026152, -6.26147828,  0.77996425, -1.44191264, -1.06231811],
         [ 0.60967989,  0.32256847,  0.45181387,  0.5811682 , -0.44032592]]),
  array([], dtype=float64),
  5,
  array([2269485.39914583,  806241.31591737,  393013.39925138,
          151874.55486185,   52663.46144239])))
```

In [69]:

```
U, S, Vh = numpy.linalg.svd(a); V = Vh.T; U, S, Vh, V
```

Out[69]:

```
(array([[[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
          -4.43058033e-17, -4.43058033e-17],
         [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
          -5.00000000e-01, -5.00000000e-01],
         [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
          -1.66666667e-01,  8.33333333e-01],
```

```
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01]],

[[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
  -4.43058033e-17, -4.43058033e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01]],

[[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
  -4.43058033e-17, -4.43058033e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01]],

[[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
  -4.43058033e-17, -4.43058033e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01]],

[[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
  -4.43058033e-17, -4.43058033e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01]],

[[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
  -4.43058033e-17, -4.43058033e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01]],

[[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
  -4.43058033e-17, -4.43058033e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01]],

[[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
```

```
         -4.43058033e-17, -4.43058033e-17],
        [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
         -5.00000000e-01, -5.00000000e-01],
        [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
         -1.66666667e-01,  8.33333333e-01],
        [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
          8.33333333e-01, -1.66666667e-01],
        [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
         -1.66666667e-01, -1.66666667e-01]],

       [[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
         -4.43058033e-17, -4.43058033e-17],
        [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
         -5.00000000e-01, -5.00000000e-01],
        [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
         -1.66666667e-01,  8.33333333e-01],
        [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
          8.33333333e-01, -1.66666667e-01],
        [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
         -1.66666667e-01, -1.66666667e-01]],

       [[-4.47213595e-01,  8.94427191e-01, -5.67184741e-17,
         -4.43058033e-17, -4.43058033e-17],
        [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
         -5.00000000e-01, -5.00000000e-01],
        [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
         -1.66666667e-01,  8.33333333e-01],
        [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
          8.33333333e-01, -1.66666667e-01],
        [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
         -1.66666667e-01, -1.66666667e-01]]]),
array([[1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00],
       [1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00],
       [1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00],
       [1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00],
       [1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00],
       [1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00],
       [1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00],
       [1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00],
       [1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00],
       [1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00]]),
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         -0.4472136 ],
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         -0.2236068 ],
        [ 0.        , -0.5       , -0.16666667, -0.16666667,
          0.83333333],
        [ 0.        , -0.5       , -0.16666667,  0.83333333,
         -0.16666667],
        [ 0.        , -0.5       ,  0.83333333, -0.16666667,
         -0.16666667]],

       [[-0.4472136 , -0.4472136 , -0.4472136 , -0.4472136 ,
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         -0.2236068 ],
        [ 0.        , -0.5       , -0.16666667, -0.16666667,
          0.83333333],
        [ 0.        , -0.5       , -0.16666667,  0.83333333,
         -0.16666667],
        [ 0.        , -0.5       ,  0.83333333, -0.16666667,
         -0.16666667]],
```

```
[[-0.4472136 , -0.4472136 , -0.4472136 , -0.4472136 ,
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  -0.2236068 ],
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   0.83333333],
 [ 0.        , -0.5       , -0.16666667,  0.83333333,
  -0.16666667],
 [ 0.        , -0.5       ,  0.83333333, -0.16666667,
  -0.16666667]],

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  -0.4472136 ],
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  -0.2236068 ],
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   0.83333333],
 [ 0.        , -0.5       , -0.16666667,  0.83333333,
  -0.16666667],
 [ 0.        , -0.5       ,  0.83333333, -0.16666667,
  -0.16666667]],

[[-0.4472136 , -0.4472136 , -0.4472136 , -0.4472136 ,
  -0.4472136 ],
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  -0.2236068 ],
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  -0.16666667]],

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  -0.2236068 ],
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   0.83333333],
 [ 0.        , -0.5       , -0.16666667,  0.83333333,
  -0.16666667],
 [ 0.        , -0.5       ,  0.83333333, -0.16666667,
  -0.16666667]],

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  -0.2236068 ],
 [ 0.        , -0.5       , -0.16666667, -0.16666667,
   0.83333333],
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  -0.16666667],
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  -0.16666667]],

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  -0.2236068 ],
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  -0.16666667],
 [ 0.        , -0.5       ,  0.83333333, -0.16666667,
  -0.16666667]],

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  -0.4472136 ],
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  -0.2236068 ],
 [ 0.        , -0.5       , -0.16666667, -0.16666667,
```

```
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          -0.16666667],
         [ 0.        , -0.5       ,  0.83333333, -0.16666667,
          -0.16666667]],

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          -0.4472136 ],
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          -0.2236068 ],
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          0.83333333],
         [ 0.        , -0.5       , -0.16666667,  0.83333333,
          -0.16666667],
         [ 0.        , -0.5       ,  0.83333333, -0.16666667,
          -0.16666667]]]),
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           0.        ,  0.        ,  0.        ,  0.        ,
           0.        ,  0.        ],
         [ 0.        ,  0.        ,  0.        ,  0.        ,
           0.        ,  0.        ,  0.        ,  0.        ,
           0.        ,  0.        ],
         [ 0.        ,  0.        ,  0.        ,  0.        ,
           0.        ,  0.        ,  0.        ,  0.        ,
           0.        ,  0.        ]],

        [[-0.4472136 , -0.4472136 , -0.4472136 , -0.4472136 ,
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          -0.4472136 , -0.4472136 ],
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          -0.2236068 , -0.2236068 , -0.2236068 , -0.2236068 ,
          -0.2236068 , -0.2236068 ],
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          -0.5       , -0.5       , -0.5       , -0.5       ,
          -0.5       , -0.5       ],
         [-0.5       , -0.5       , -0.5       , -0.5       ,
          -0.5       , -0.5       , -0.5       , -0.5       ,
          -0.5       , -0.5       ],
         [-0.5       , -0.5       , -0.5       , -0.5       ,
          -0.5       , -0.5       , -0.5       , -0.5       ,
          -0.5       , -0.5       ]],

        [[-0.4472136 , -0.4472136 , -0.4472136 , -0.4472136 ,
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          -0.4472136 , -0.4472136 ],
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          -0.16666667, -0.16666667],
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           0.83333333,  0.83333333]],

        [[-0.4472136 , -0.4472136 , -0.4472136 , -0.4472136 ,
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          -0.2236068 , -0.2236068 ],
         [-0.16666667, -0.16666667, -0.16666667, -0.16666667,
          -0.16666667, -0.16666667, -0.16666667, -0.16666667,
```

```
          -0.16666667, -0.16666667],
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           0.83333333,  0.83333333],
         [-0.16666667, -0.16666667, -0.16666667, -0.16666667,
          -0.16666667, -0.16666667, -0.16666667, -0.16666667,
          -0.16666667, -0.16666667]],

        [[-0.4472136 , -0.4472136 , -0.4472136 , -0.4472136 ,
          -0.4472136 , -0.4472136 , -0.4472136 , -0.4472136 ,
          -0.4472136 , -0.4472136 ],
         [-0.2236068 , -0.2236068 , -0.2236068 , -0.2236068 ,
          -0.2236068 , -0.2236068 , -0.2236068 , -0.2236068 ,
          -0.2236068 , -0.2236068 ],
         [ 0.83333333,  0.83333333,  0.83333333,  0.83333333,
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           0.83333333,  0.83333333],
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          -0.16666667, -0.16666667, -0.16666667, -0.16666667,
          -0.16666667, -0.16666667],
         [-0.16666667, -0.16666667, -0.16666667, -0.16666667,
          -0.16666667, -0.16666667, -0.16666667, -0.16666667,
          -0.16666667, -0.16666667]]]))
```

In [70]:

```
numpy.linalg.cholesky(numpy.eye(5) * numpy.array([5, 15, 10, 20, 25]))
```

Out[70]:

```
array([[2.23606798, 0.        , 0.        , 0.        , 0.        ],
       [0.        , 3.87298335, 0.        , 0.        , 0.        ],
       [0.        , 0.        , 3.16227766, 0.        , 0.        ],
       [0.        , 0.        , 0.        , 4.47213595, 0.        ],
       [0.        , 0.        , 0.        , 0.        , 5.        ]])
```

In [71]:

```
D,V = numpy.linalg.eig(a); D, V
```

Out[71]:

```
(array([[ 0., 15.,  0.,  0.,  0.],
        [ 0., 15.,  0.,  0.,  0.],
        [ 0., 15.,  0.,  0.,  0.],
        [ 0., 15.,  0.,  0.,  0.],
        [ 0., 15.,  0.,  0.,  0.],
        [ 0., 15.,  0.,  0.,  0.],
        [ 0., 15.,  0.,  0.,  0.],
        [ 0., 15.,  0.,  0.,  0.],
        [ 0., 15.,  0.,  0.,  0.],
        [ 0., 15.,  0.,  0.,  0.]]),
 array([[[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
           0.        ],
         [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
          -0.5       ],
         [ 0.2236068 ,  0.4472136 ,  0.83333333, -0.16666667,
          -0.16666667],
         [ 0.2236068 ,  0.4472136 , -0.16666667,  0.83333333,
          -0.16666667],
         [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
           0.83333333]],

        [[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
           0.        ],
         [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
          -0.5       ],
         [ 0.2236068 ,  0.4472136 ,  0.83333333, -0.16666667,
          -0.16666667],
         [ 0.2236068 ,  0.4472136 , -0.16666667,  0.83333333,
          -0.16666667],
         [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
           0.83333333]],
```

```
    0.83333333]],

  [[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
     0.        ],
   [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
    -0.5       ],
   [ 0.2236068 ,  0.4472136 ,  0.83333333, -0.16666667,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667,  0.83333333,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
     0.83333333]],

  [[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
     0.        ],
   [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
    -0.5       ],
   [ 0.2236068 ,  0.4472136 ,  0.83333333, -0.16666667,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667,  0.83333333,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
     0.83333333]],

  [[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
     0.        ],
   [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
    -0.5       ],
   [ 0.2236068 ,  0.4472136 ,  0.83333333, -0.16666667,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667,  0.83333333,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
     0.83333333]],

  [[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
     0.        ],
   [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
    -0.5       ],
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    -0.16666667],
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    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
     0.83333333]],

  [[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
     0.        ],
   [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
    -0.5       ],
   [ 0.2236068 ,  0.4472136 ,  0.83333333, -0.16666667,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667,  0.83333333,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
     0.83333333]],

  [[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
     0.        ],
   [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
    -0.5       ],
   [ 0.2236068 ,  0.4472136 ,  0.83333333, -0.16666667,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667,  0.83333333,
    -0.16666667],
   [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
     0.83333333]],

  [[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
     0.        ],
   [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
    -0.5       ],
   [ 0.2236068 ,  0.4472136 ,  0.83333333, -0.16666667,
```

```
         -0.16666667],
        [ 0.2236068 ,  0.4472136 , -0.16666667,  0.83333333,
         -0.16666667],
        [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
          0.83333333]],

       [[-0.89442719,  0.4472136 ,  0.        ,  0.        ,
          0.        ],
        [ 0.2236068 ,  0.4472136 , -0.5       , -0.5       ,
         -0.5       ],
        [ 0.2236068 ,  0.4472136 ,  0.83333333, -0.16666667,
         -0.16666667],
        [ 0.2236068 ,  0.4472136 , -0.16666667,  0.83333333,
         -0.16666667],
        [ 0.2236068 ,  0.4472136 , -0.16666667, -0.16666667,
          0.83333333]]]))
```

In [72]:

```
D,V = scipy.sparse.linalg.eigs(a[0].astype(float), k=3); D, V
```

Out[72]:

```
(array([1.50000000e+01+0.j, 8.04401668e-32+0.j, 2.08015975e-32+0.j]),
 array([[ 0.4472136 +0.j, -0.05591485+0.j,  0.26602444+0.j],
        [ 0.4472136 +0.j, -0.08702376+0.j,  0.29986749+0.j],
        [ 0.4472136 +0.j, -0.17135137+0.j, -0.43453756+0.j],
        [ 0.4472136 +0.j, -0.51759571+0.j, -0.63218429+0.j],
        [ 0.4472136 +0.j,  0.83188568+0.j,  0.50082993+0.j]]))
```

In [73]:

```
Q,R = numpy.linalg.qr(a); Q, R
```

Out[73]:

```
(array([[[-4.47213595e-01,  8.94427191e-01, -4.43058033e-17,
          -4.43058033e-17, -5.67184741e-17],
         [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
          -5.00000000e-01, -5.00000000e-01],
         [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
          -1.66666667e-01, -1.66666667e-01],
         [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
           8.33333333e-01, -1.66666667e-01],
         [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
          -1.66666667e-01,  8.33333333e-01]],

        [[-4.47213595e-01,  8.94427191e-01, -4.43058033e-17,
          -4.43058033e-17, -5.67184741e-17],
         [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
          -5.00000000e-01, -5.00000000e-01],
         [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
          -1.66666667e-01, -1.66666667e-01],
         [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
           8.33333333e-01, -1.66666667e-01],
         [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
          -1.66666667e-01,  8.33333333e-01]],

        [[-4.47213595e-01,  8.94427191e-01, -4.43058033e-17,
          -4.43058033e-17, -5.67184741e-17],
         [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
          -5.00000000e-01, -5.00000000e-01],
         [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
          -1.66666667e-01, -1.66666667e-01],
         [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
           8.33333333e-01, -1.66666667e-01],
         [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
          -1.66666667e-01,  8.33333333e-01]],

        [[-4.47213595e-01,  8.94427191e-01, -4.43058033e-17,
          -4.43058033e-17, -5.67184741e-17],
         [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
```

```
  -5.00000000e-01, -5.00000000e-01],
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  -1.66666667e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01]],

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  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01]],

[[-4.47213595e-01,  8.94427191e-01, -4.43058033e-17,
  -4.43058033e-17, -5.67184741e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01]],

[[-4.47213595e-01,  8.94427191e-01, -4.43058033e-17,
  -4.43058033e-17, -5.67184741e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01]],

[[-4.47213595e-01,  8.94427191e-01, -4.43058033e-17,
  -4.43058033e-17, -5.67184741e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01]],

[[-4.47213595e-01,  8.94427191e-01, -4.43058033e-17,
  -4.43058033e-17, -5.67184741e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
  -1.66666667e-01,  8.33333333e-01]],

[[-4.47213595e-01,  8.94427191e-01, -4.43058033e-17,
  -4.43058033e-17, -5.67184741e-17],
 [-4.47213595e-01, -2.23606798e-01, -5.00000000e-01,
  -5.00000000e-01, -5.00000000e-01],
 [-4.47213595e-01, -2.23606798e-01,  8.33333333e-01,
  -1.66666667e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
   8.33333333e-01, -1.66666667e-01],
 [-4.47213595e-01, -2.23606798e-01, -1.66666667e-01,
```

```
         -1.66666667e-01,  8.33333333e-01]]]),
 array([[[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]],

        [[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]],

        [[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]],

        [[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]],

        [[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]],

        [[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]],

        [[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]],

        [[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]],

        [[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]],

        [[-6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
          -6.70820393e+00, -6.70820393e+00],
         [ 0.00000000e+00, -1.77635684e-15, -1.77635684e-15,
          -1.77635684e-15, -1.77635684e-15],
         [ 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]]]))
```

In [74]:

```
P,L,U = scipy.linalg.lu(a[0]); P, L, U
```

Out[74]:

```
(array([[1., 0., 0., 0., 0.],
        [0., 1., 0., 0., 0.],
        [0., 0., 1., 0., 0.],
        [0., 0., 0., 1., 0.],
        [0., 0., 0., 0., 1.]]),
 array([[1., 0., 0., 0., 0.],
        [1., 1., 0., 0., 0.],
        [1., 0., 1., 0., 0.],
        [1., 0., 0., 1., 0.],
        [1., 0., 0., 0., 1.]]),
 array([[3., 3., 3., 3., 3.],
        [0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.],
        [0., 0., 0., 0., 0.]]))
```

In [75]:

```
numpy.conjugate(a)
```

Out[75]:

```
array([[[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],
```

```
       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]]])
```

In [76]:

```
numpy.fft.fft(a)
```

Out[76]:

```
array([[[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]],

       [[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]],
```

```
       [[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]],

       [[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]],

       [[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]],

       [[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]],

       [[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]],

       [[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]],

       [[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]],

       [[15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j],
        [15.+0.j,  0.+0.j,  0.+0.j,  0.+0.j,  0.+0.j]]])
```

In [77]:

```
numpy.fft.ifft(a)
```

Out[77]:

```
array([[[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]],

       [[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]],

       [[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]],

       [[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
```

```
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]],

       [[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]],

       [[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]],

       [[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]],

       [[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]],

       [[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]],

       [[3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j],
        [3.+0.j, 0.+0.j, 0.+0.j, 0.+0.j, 0.+0.j]]]])
```

In [78]:

```
numpy.sort(a), a.sort(axis=0)
```

Out[78]:

```
(array([[[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
```

```
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]]]),
 None)
```

In [79]:

```
numpy.sort(a, axis=1), a.sort(axis=1)
```

Out[79]:

```
(array([[[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]],
```

```
         [[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]],

         [[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]],

         [[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]],

         [[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]],

         [[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]]]]),
 None)
```

In [80]:

```
I = numpy.argsort(a[:, 0]); b = a[I,:]; b
```

Out[80]:

```
array([[[[[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]],

         [[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]],

         [[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]],

         [[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]],

         [[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]]],


        [[[3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3],
          [3, 3, 3, 3, 3]]
```

```
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]]],


[[[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]]],


...,


[[[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],
```

```
 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]]],


[[[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]]],


[[[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]],

 [[3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3],
  [3, 3, 3, 3, 3]
```

```
         [3, 3, 3, 3, 3]],

        [[3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3],
         [3, 3, 3, 3, 3]]]])
```

In [81]:

```
l = numpy.linalg.lstsq(a[-3], a[-3]); l
```

```
/var/folders/7k/wfdc1r714qgglwzkz4_kmf3rybjsnh/T/ipykernel_26882/1058284234.py:1: FutureW
arning: `rcond` parameter will change to the default of machine precision times ``max(M,
N)`` where M and N are the input matrix dimensions.
To use the future default and silence this warning we advise to pass `rcond=None`, to kee
p using the old, explicitly pass `rcond=-1`.
  l = numpy.linalg.lstsq(a[-3], a[-3]); l
```

Out[81]:

```
(array([[0.2, 0.2, 0.2, 0.2, 0.2],
        [0.2, 0.2, 0.2, 0.2, 0.2],
        [0.2, 0.2, 0.2, 0.2, 0.2],
        [0.2, 0.2, 0.2, 0.2, 0.2],
        [0.2, 0.2, 0.2, 0.2, 0.2]]),
 array([], dtype=float64),
 1,
 array([1.50000000e+01, 1.58882186e-15, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00]))
```

In [82]:

```
scipy.signal.resample(a, int(numpy.ceil(len(a)/2)))
```

Out[82]:

```
array([[[[3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.]],

        [[3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.]],

        [[3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.]],

        [[3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.]],

        [[3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.],
         [3., 3., 3., 3., 3.]]]])
```

In [83]:

```
numpy.unique(a)
```

Out[83]:

```
array([3])
```

In [84]:

```
a.squeeze()
```

Out[84]:

```
array([[[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]],

       [[3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3],
        [3, 3, 3, 3, 3]]])
```