

# Assignment 0 - COMP 576

---

## Zan (Tian) Zhang

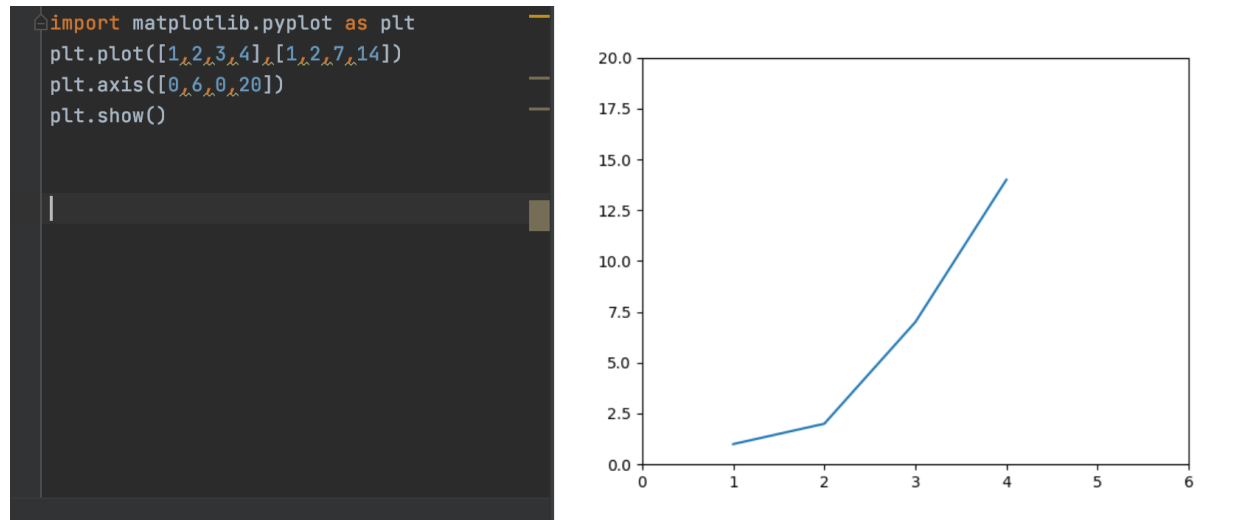
### 1. Conda info

```
active environment : base
active env location : /Users/zanzhang/opt/anaconda3
shell level        : 2
user config file   : /Users/zanzhang/.condarc
populated config files : /Users/zanzhang/.condarc
conda version      : 4.9.2
conda-build version : 3.20.5
python version     : 3.8.5.final.0
virtual packages   : __osx=10.16=0
                   __unix=0=0
                   __archspec=1=x86_64
base environment   : /Users/zanzhang/opt/anaconda3 (writable)
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/zanzhang/opt/anaconda3/pkgs
                   /Users/zanzhang/.conda/pkgs
envs directories   : /Users/zanzhang/opt/anaconda3/envs
                   /Users/zanzhang/.conda/envs
platform          : osx-64
user-agent         : conda/4.9.2 requests/2.24.0 CPython/3.8.5 Darwin/21.5.0 OSX/10.16
UID:GID           : 501:20
netrc file         : /Users/zanzhang/.netrc
offline mode       : False

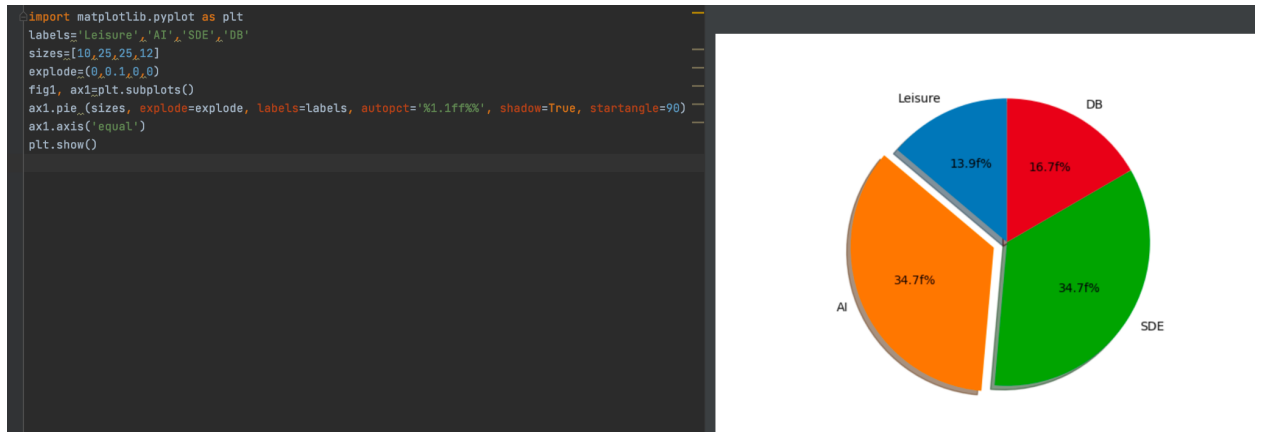
(base) Sweets-Mac-Pro:~ zanzhang$
```

### 2. See below

### 3. Task 3



#### 4. Task 4



#### 5. Github account: zzhang786



6. [https://github.com/zzhang786/zz93\\_Assignment\\_0](https://github.com/zzhang786/zz93_Assignment_0)

History:

# Untitled

September 14, 2022

```
[8]: import numpy as np
import scipy.linalg
```

```
[9]: a=np.arange(20).reshape(4,5)
a
```

```
[9]: array([[ 0,  1,  2,  3,  4],
          [ 5,  6,  7,  8,  9],
          [10, 11, 12, 13, 14],
          [15, 16, 17, 18, 19]])
```

```
[10]: a.ndim
```

```
[10]: 2
```

```
[11]: a.size
```

```
[11]: 20
```

```
[12]: a.shape
```

```
[12]: (4, 5)
```

```
[14]: a.shape[2-1]
```

```
[14]: 5
```

```
[15]: a.shape[1-1]
```

```
[15]: 4
```

```
[16]: a.shape[0-1]
```

```
[16]: 5
```

```
[17]: a.shape[2-1]
```

```
[17]: 5
```

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

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

```
[20]: np.block([[1, 2], [3, 4]])
```

```
[20]: array([[1, 2],  
           [3, 4]])
```

```
[21]: a[-1]
```

```
[21]: array([15, 16, 17, 18, 19])
```

```
[22]: a[1, 4]
```

```
[22]: 9
```

```
[23]: a[1]
```

```
[23]: array([5, 6, 7, 8, 9])
```

```
[24]: a[0:5]
```

```
[24]: array([[ 0,  1,  2,  3,  4],  
           [ 5,  6,  7,  8,  9],  
           [10, 11, 12, 13, 14],  
           [15, 16, 17, 18, 19]])
```

```
[27]: a=np.arange(49).reshape(7,7)  
a
```

```
[27]: array([[ 0,  1,  2,  3,  4,  5,  6],  
           [ 7,  8,  9, 10, 11, 12, 13],  
           [14, 15, 16, 17, 18, 19, 20],  
           [21, 22, 23, 24, 25, 26, 27],  
           [28, 29, 30, 31, 32, 33, 34],  
           [35, 36, 37, 38, 39, 40, 41],  
           [42, 43, 44, 45, 46, 47, 48]])
```

```
[28]: a[0:5]
```

```
[28]: array([[ 0,  1,  2,  3,  4,  5,  6],  
           [ 7,  8,  9, 10, 11, 12, 13],  
           [14, 15, 16, 17, 18, 19, 20],  
           [21, 22, 23, 24, 25, 26, 27],  
           [28, 29, 30, 31, 32, 33, 34]])
```

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

```
[29]: array([[14, 15, 16, 17, 18, 19, 20],
           [21, 22, 23, 24, 25, 26, 27],
           [28, 29, 30, 31, 32, 33, 34],
           [35, 36, 37, 38, 39, 40, 41],
           [42, 43, 44, 45, 46, 47, 48]])
```

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

```
[30]: array([[ 4,  5,  6],
           [11, 12, 13],
           [18, 19, 20]])
```

```
[47]: a=np.arange(25).reshape(5,5)
```

```
a[0:5]#[Out]# array([[ 0,  1,  2,  3,  4],
```

```
[47]: array([[ 0,  1,  2,  3,  4],
           [ 5,  6,  7,  8,  9],
           [10, 11, 12, 13, 14],
           [15, 16, 17, 18, 19],
           [20, 21, 22, 23, 24]])
```

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

```
[33]: array([[ 0,  1,  2,  3,  4],
           [ 5,  6,  7,  8,  9],
           [10, 11, 12, 13, 14],
           [15, 16, 17, 18, 19]])
```

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

```
[35]: array([[ 4],
           [ 9],
           [14]])
```

```
[48]: a[np.ix_([1, 3, 4], [0, 2])]
```

```
[48]: array([[ 5,  7],
           [15, 17],
           [20, 22]])
```

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

```
[49]: array([[10, 11, 12, 13, 14],
           [20, 21, 22, 23, 24]])
```

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

```
[50]: array([[ 0,  1,  2,  3,  4],  
           [10, 11, 12, 13, 14],  
           [20, 21, 22, 23, 24]])
```

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

```
[51]: array([[20, 21, 22, 23, 24],  
           [15, 16, 17, 18, 19],  
           [10, 11, 12, 13, 14],  
           [ 5,  6,  7,  8,  9],  
           [ 0,  1,  2,  3,  4]])
```

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

```
[52]: array([[ 0,  1,  2,  3,  4],  
           [ 5,  6,  7,  8,  9],  
           [10, 11, 12, 13, 14],  
           [15, 16, 17, 18, 19],  
           [20, 21, 22, 23, 24],  
           [ 0,  1,  2,  3,  4]])
```

```
[53]: a.transpose()
```

```
[53]: array([[ 0,  5, 10, 15, 20],  
           [ 1,  6, 11, 16, 21],  
           [ 2,  7, 12, 17, 22],  
           [ 3,  8, 13, 18, 23],  
           [ 4,  9, 14, 19, 24]])
```

```
[54]: a.conj().transpose()
```

```
[54]: array([[ 0,  5, 10, 15, 20],  
           [ 1,  6, 11, 16, 21],  
           [ 2,  7, 12, 17, 22],  
           [ 3,  8, 13, 18, 23],  
           [ 4,  9, 14, 19, 24]])
```

```
[60]: b=np.arange(25).reshape(5,5)  
b
```

```
[60]: array([[ 0,  1,  2,  3,  4],  
           [ 5,  6,  7,  8,  9],  
           [10, 11, 12, 13, 14],  
           [15, 16, 17, 18, 19],  
           [20, 21, 22, 23, 24]])
```

```
[61]: a @ b
```

```
[61]: array([[ 150,  160,  170,  180,  190],
           [ 400,  435,  470,  505,  540],
           [ 650,  710,  770,  830,  890],
           [ 900,  985, 1070, 1155, 1240],
           [1150, 1260, 1370, 1480, 1590]])
```

```
[62]: a * b
```

```
[62]: array([[ 0,  1,  4,  9, 16],
           [25, 36, 49, 64, 81],
           [100, 121, 144, 169, 196],
           [225, 256, 289, 324, 361],
           [400, 441, 484, 529, 576]])
```

```
[63]: a/b
```

```
/var/folders/c3/x6v88t2n49793nvyhs2wv48m0000gn/T/ipykernel_93034/1348051284.py:1
: RuntimeWarning: invalid value encountered in true_divide
a/b
```

```
[63]: array([[nan,  1.,  1.,  1.,  1.],
           [ 1.,  1.,  1.,  1.,  1.],
           [ 1.,  1.,  1.,  1.,  1.],
           [ 1.,  1.,  1.,  1.,  1.],
           [ 1.,  1.,  1.,  1.,  1.]])
```

```
[64]: a**3
```

```
[64]: array([[ 0,  1,  8, 27, 64],
           [125, 216, 343, 512, 729],
           [1000, 1331, 1728, 2197, 2744],
           [3375, 4096, 4913, 5832, 6859],
           [8000, 9261, 10648, 12167, 13824]])
```

```
[65]: (a > 0.5)
```

```
[65]: array([[False,  True,  True,  True,  True],
           [ True,  True,  True,  True,  True],
           [ True,  True,  True,  True,  True],
           [ True,  True,  True,  True,  True],
           [ True,  True,  True,  True,  True]])
```

```
[66]: np.nonzero(a > 0.5)
```



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

```
[68]: np.nonzero(a>0.5)
```

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

```
[77]: v=np.arange(20).reshape(4,5)
      a[:,np.nonzero(v>0.5)[0]]
```

```
[77]: array([[ 0,  0,  0,  0,  1,  1,  1,  1,  1,  2,  2,  2,  2,  2,  3,  3,
            3,  3,  3],
            [ 5,  5,  5,  5,  6,  6,  6,  6,  6,  7,  7,  7,  7,  7,  8,  8,
            8,  8,  8],
            [10, 10, 10, 10, 11, 11, 11, 11, 11, 12, 12, 12, 12, 12, 13, 13,
            13, 13, 13],
            [15, 15, 15, 15, 16, 16, 16, 16, 16, 17, 17, 17, 17, 17, 18, 18,
            18, 18, 18],
            [20, 20, 20, 20, 21, 21, 21, 21, 21, 22, 22, 22, 22, 22, 23, 23,
            23, 23, 23]])
```

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

```
[85]: array([[False,  True,  True,  True],
            [ True,  True,  True,  True],
            [ True,  True,  True,  True],
            [ True,  True,  True,  True],
            [ True,  True,  True,  True]])
```

```
[91]: v=np.array([[1],[2],[3],[4],[0.1]])
      v
```

```
[91]: array([[1. ],
            [2. ],
            [3. ],
            [4. ],
            [0.1]])
```

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

```
[94]: array([[ 0,  1,  2,  3,  4],
           [ 5,  6,  7,  8,  9],
           [10, 11, 12, 13, 14],
           [15, 16, 17, 18, 19],
           [20, 21, 22, 23, 24]])
```

```
[95]: a * (a > 0.5)
a
```

```
[95]: array([[ 0,  1,  2,  3,  4],
           [ 5,  6,  7,  8,  9],
           [10, 11, 12, 13, 14],
           [15, 16, 17, 18, 19],
           [20, 21, 22, 23, 24]])
```

```
[97]: a[:] = 3
a
```

```
[97]: 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]])
```

```
[100]: y = a.copy()
y
```

```
[100]: 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]])
```

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

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

```
[104]: y = a.flatten()
y
```

```
[104]: 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])
```

```
[105]: np.arange(1., 11.)
```

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

```
[106]: np.r_[10.]
```

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

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

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

```
[108]: np.zeros((3, 4))
```

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

```
[109]: np.zeros((3, 4, 5))
```

```
[109]: 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.]])
```

```
[110]: np.ones((3, 4))
```

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

```
[111]: np.eye(3)
```

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

```
[112]: np.diag(a)
```

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

```
[113]: np.diag(v, 0)
```

```
[113]: array([1.])
```

```
[126]: from numpy.random import default_rng
rng = default_rng(42)
rng.random((3, 4))
```

```
[126]: 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]])
```

```
[127]: np.linspace(1,3,4)
```

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

```
[129]: np.mgrid[0:9.,0:6.]
```

```
[129]: 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.]])
```

```
[132]: np.ogrid[0:9.,0:6.]
```

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

```
[133]: np.meshgrid([1,2,4],[2,4,5])
```

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

```
[141]: np.ix_([1,2,4],[2,4,5])
```

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

```
[143]: np.tile(a, (3, 4))
```

```
[143]: 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]])
```

```
[144]: np.concatenate((a,b),1)
```

```
[144]: array([[ 3,  3,  3,  3,  3,  0,  1,  2,  3,  4],
              [ 3,  3,  3,  3,  3,  5,  6,  7,  8,  9],
              [ 3,  3,  3,  3,  3, 10, 11, 12, 13, 14],
              [ 3,  3,  3,  3,  3, 15, 16, 17, 18, 19],
              [ 3,  3,  3,  3,  3, 20, 21, 22, 23, 24]])
```

```
[145]: np.concatenate((a,b))
```

```
[145]: 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],
              [ 0,  1,  2,  3,  4],
              [ 5,  6,  7,  8,  9],
              [10, 11, 12, 13, 14],
              [15, 16, 17, 18, 19],
              [20, 21, 22, 23, 24]])
```

```
[146]: a.max()
```

```
[146]: 3
```

```
[147]: a.max(0)
```

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

```
[148]: a.max(1)
```

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

```
[149]: np.maximum(a, b)
```

```
[149]: array([[ 3,  3,  3,  3,  4],
              [ 5,  6,  7,  8,  9],
              [10, 11, 12, 13, 14],
              [15, 16, 17, 18, 19],
              [20, 21, 22, 23, 24]])
```

```
[151]: np.sqrt(a @ b)
```

```
[151]: array([[12.24744871, 12.84523258, 13.41640786, 13.96424004, 14.49137675],
              [12.24744871, 12.84523258, 13.41640786, 13.96424004, 14.49137675],
              [12.24744871, 12.84523258, 13.41640786, 13.96424004, 14.49137675],
              [12.24744871, 12.84523258, 13.41640786, 13.96424004, 14.49137675],
              [12.24744871, 12.84523258, 13.41640786, 13.96424004, 14.49137675]])
```

```
[153]: np.logical_and(a,b)
```

```
[153]: array([[False,  True,  True,  True,  True],
             [ True,  True,  True,  True,  True],
             [ True,  True,  True,  True,  True],
             [ True,  True,  True,  True,  True],
             [ True,  True,  True,  True,  True]])
```

```
[154]: np.logical_or(a,b)
```

```
[154]: 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]])
```

```
[155]: a & b
```

```
[155]: array([[0, 1, 2, 3, 0],
             [1, 2, 3, 0, 1],
             [2, 3, 0, 1, 2],
             [3, 0, 1, 2, 3],
             [0, 1, 2, 3, 0]])
```

```
[156]: a | b
```

```
[156]: array([[ 3,  3,  3,  3,  7],
             [ 7,  7,  7, 11, 11],
             [11, 11, 15, 15, 15],
             [15, 19, 19, 19, 19],
             [23, 23, 23, 23, 27]])
```

```
[167]: c = np.array([[1., 2.], [3., 4.]])
       np.linalg.inv(c)
```

```
[167]: array([[ -2. ,  1. ],
             [ 1.5, -0.5]])
```

```
[168]: np.linalg.pinv(a)
```

```
[168]: 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]])
```

```
[170]: np.linalg.matrix_rank(a)
```

```
[170]: 1
```

```
[272]: np.linalg.lstsq(a, b, rcond=None)
```

```
[272]: (array([[ -0.02470314, -0.99426878,  0.24219306, -1.14861772, -0.45412453],
               [-1.57705109, -0.14924059,  0.45581515, -0.19976327, -0.1638319 ],
               [-1.46953047, -1.97687497, -0.39631202, -2.63141169, -1.54497317],
               [-0.27431161, -1.07540872,  0.03782807, -2.75632378, -1.24713453],
               [ 3.20349588,  3.7034493 ,  0.33499671,  5.27929192,  3.32657953]]),
        array([], dtype=float64),
        5,
        array([2.65088822, 0.8711694 , 0.63173817, 0.3178289 , 0.11755287]))
```

```
[273]: np.linalg.solve(a.T, b.T)
```

```
[273]: array([[ 0.00000000e+00, -2.76036162e-17,  0.00000000e+00,
               1.00000000e+00, -2.18879201e-17],
               [ 0.00000000e+00,  2.30117314e-17,  1.00000000e+00,
               2.64098866e-17,  4.91314893e-17],
               [ 0.00000000e+00,  3.82746311e-17, -7.57194853e-18,
               5.73068798e-17,  1.00000000e+00],
               [ 1.00000000e+00, -2.26739682e-17,  4.06700635e-17,
               -6.28095737e-18, -4.91652864e-17],
               [-1.68592397e-17,  1.00000000e+00, -8.26305469e-17,
               -8.63574988e-17,  4.33516032e-17]])
```

```
[179]: U, S, Vh = np.linalg.svd(a);
        V = Vh.T

        V
```

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

```
[188]: A = np.array([[1,-2j],[2j,5]])

        L = np.linalg.cholesky(A)
        L
```

```
[188]: array([[1.+0.j, 0.+0.j],
               [0.+2.j, 1.+0.j]])
```



```
[191]: D,V = np.linalg.eig(a)
D
```

```
[191]: array([1.50000000e+01+0.00000000e+00j, 1.10535203e-32+1.49491076e-24j,
            1.10535203e-32-1.49491076e-24j, 0.00000000e+00+0.00000000e+00j,
            9.27495619e-65+0.00000000e+00j])
```

```
[192]: V
```

```
[192]: array([[ -4.47213595e-01+0.00000000e+00j,  3.05673275e-17+5.18266518e-09j,
              3.05673275e-17-5.18266518e-09j, -4.87104483e-49+0.00000000e+00j,
              -9.50718352e-50+0.00000000e+00j],
             [ -4.47213595e-01+0.00000000e+00j,  8.66025404e-01+0.00000000e+00j,
              8.66025404e-01-0.00000000e+00j, -3.09522653e-32+0.00000000e+00j,
              2.79765981e-16+0.00000000e+00j],
             [ -4.47213595e-01+0.00000000e+00j, -2.88675135e-01-1.72755506e-09j,
              -2.88675135e-01+1.72755506e-09j, -2.98122760e-16+0.00000000e+00j,
              8.16496581e-01+0.00000000e+00j],
             [ -4.47213595e-01+0.00000000e+00j, -2.88675135e-01-1.72755506e-09j,
              -2.88675135e-01+1.72755506e-09j, -7.07106781e-01+0.00000000e+00j,
              -4.08248290e-01+0.00000000e+00j],
             [ -4.47213595e-01+0.00000000e+00j, -2.88675135e-01-1.72755506e-09j,
              -2.88675135e-01+1.72755506e-09j,  7.07106781e-01+0.00000000e+00j,
              -4.08248290e-01+0.00000000e+00j]])
```

```
[220]: w, v = np.linalg.eig((a, b))
w
```

```
[220]: array([[ 1.50000000e+01+0.00000000e+00j,  1.10535203e-32+1.49491076e-24j,
              1.10535203e-32-1.49491076e-24j,  0.00000000e+00+0.00000000e+00j,
              9.27495619e-65+0.00000000e+00j],
             [ 6.39116499e+01+0.00000000e+00j, -3.91164992e+00+0.00000000e+00j,
              3.19626490e-15+0.00000000e+00j, -1.64396509e-15+0.00000000e+00j,
              8.90756696e-17+0.00000000e+00j]])
```

```
[221]: v
```

```
[221]: array([[ -4.47213595e-01+0.00000000e+00j,
              3.05673275e-17+5.18266518e-09j,
              3.05673275e-17-5.18266518e-09j,
              -4.87104483e-49+0.00000000e+00j,
              -9.50718352e-50+0.00000000e+00j],
             [ -4.47213595e-01+0.00000000e+00j,
              8.66025404e-01+0.00000000e+00j,
              8.66025404e-01-0.00000000e+00j,
              -3.09522653e-32+0.00000000e+00j,
              2.79765981e-16+0.00000000e+00j],
```

```

[-4.47213595e-01+0.00000000e+00j,
 -2.88675135e-01-1.72755506e-09j,
 -2.88675135e-01+1.72755506e-09j,
 -2.98122760e-16+0.00000000e+00j,
  8.16496581e-01+0.00000000e+00j],
[-4.47213595e-01+0.00000000e+00j,
 -2.88675135e-01-1.72755506e-09j,
 -2.88675135e-01+1.72755506e-09j,
 -7.07106781e-01+0.00000000e+00j,
 -4.08248290e-01+0.00000000e+00j],
[-4.47213595e-01+0.00000000e+00j,
 -2.88675135e-01-1.72755506e-09j,
 -2.88675135e-01+1.72755506e-09j,
  7.07106781e-01+0.00000000e+00j,
 -4.08248290e-01+0.00000000e+00j]],

[[-8.51802044e-02+0.00000000e+00j,
  6.77798642e-01+0.00000000e+00j,
  6.94530680e-02+0.00000000e+00j,
 -3.91484356e-01+0.00000000e+00j,
 -1.09858325e-01+0.00000000e+00j],
 [-2.38253717e-01+0.00000000e+00j,
  3.63488728e-01+0.00000000e+00j,
  4.40322277e-01+0.00000000e+00j,
  2.90591999e-01+0.00000000e+00j,
 -3.33805478e-02+0.00000000e+00j],
 [-3.91327229e-01+0.00000000e+00j,
  4.91788140e-02+0.00000000e+00j,
 -5.72004887e-01+0.00000000e+00j,
  1.85712658e-02+0.00000000e+00j,
  6.33521649e-01+0.00000000e+00j],
 [-5.44400741e-01+0.00000000e+00j,
 -2.65131100e-01+0.00000000e+00j,
 -4.54769328e-01+0.00000000e+00j,
  6.57018896e-01+0.00000000e+00j,
 -7.27468356e-01+0.00000000e+00j],
 [-6.97474253e-01+0.00000000e+00j,
 -5.79441014e-01+0.00000000e+00j,
  5.16998870e-01+0.00000000e+00j,
 -5.74697805e-01+0.00000000e+00j,
  2.37185580e-01+0.00000000e+00j]]])

```

```

[229]: from scipy.sparse.linalg import eigs
       D, V = eigs(np.eye(5), k=3)
       D

```

```

[229]: array([1.+0.j, 1.+0.j, 1.+0.j])

```

```
[230]: V
```

```
[230]: array([[ 0.73493183+0.j,  0.29509892+0.j,  0.27007783+0.j],
             [-0.25460993+0.j,  0.34494288+0.j, -0.33995228+0.j],
             [ 0.34159688+0.j, -0.37974661+0.j, -0.81110163+0.j],
             [ 0.52749507+0.j,  0.13582134+0.j, -0.0330806 +0.j],
             [ 0.01046501+0.j, -0.79452886+0.j,  0.39052559+0.j]])
```

```
[215]: Q,R = np.linalg.qr(a)
       Q
```

```
[215]: array([[ -4.47213595e-01,  8.94427191e-01, -4.01682464e-17,
                0.00000000e+00,  0.00000000e+00],
             [ -4.47213595e-01, -2.23606798e-01,  8.66025404e-01,
                0.00000000e+00,  2.14690125e-18],
             [ -4.47213595e-01, -2.23606798e-01, -2.88675135e-01,
                8.16496581e-01, -8.68448956e-17],
             [ -4.47213595e-01, -2.23606798e-01, -2.88675135e-01,
                -4.08248290e-01, -7.07106781e-01],
             [ -4.47213595e-01, -2.23606798e-01, -2.88675135e-01,
                -4.08248290e-01,  7.07106781e-01]])
```

```
[216]: R
```

```
[216]: array([[ -6.70820393e+00, -6.70820393e+00, -6.70820393e+00,
                -6.70820393e+00, -6.70820393e+00],
             [  0.00000000e+00, -1.44688132e-15, -1.44688132e-15,
                -1.44688132e-15, -1.44688132e-15],
             [  0.00000000e+00,  0.00000000e+00, -1.26263380e-32,
                -1.26263380e-32, -1.26263380e-32],
             [  0.00000000e+00,  0.00000000e+00,  0.00000000e+00,
                6.52838235e-49,  6.52838235e-49],
             [  0.00000000e+00,  0.00000000e+00,  0.00000000e+00,
                0.00000000e+00, -9.51666664e-66]])
```

```
[232]: from scipy.linalg import lu
       P,L,U = lu(a)
       P
```

```
[232]: 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.]])
```

```
[233]: L
```

```
[233]: 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.]])
```

```
[234]: U
```

```
[234]: 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.]])
```

```
[235]: np.fft.fft(a)
```

```
[235]: 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]])
```

```
[236]: np.fft.ifft(a)
```

```
[236]: 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]])
```

```
[250]: a = np.random.rand(5,5)
```

```
[251]: np.sort(a)
```

```
[251]: array([[0.13382594, 0.38810458, 0.62843572, 0.70302585, 0.81114902],
             [0.03135856, 0.36136427, 0.54705689, 0.59120535, 0.73782371],
             [0.19279555, 0.64519405, 0.67682124, 0.72091305, 0.96818829],
             [0.10955931, 0.59617498, 0.60177775, 0.8718779 , 0.95801931],
             [0.09933875, 0.20403836, 0.21766352, 0.3926468 , 0.48003049]])
```

```
[255]: np.sort(a, axis=1)
```

```
[255]: array([[0.13382594, 0.38810458, 0.62843572, 0.70302585, 0.81114902],
             [0.03135856, 0.36136427, 0.54705689, 0.59120535, 0.73782371],
             [0.19279555, 0.64519405, 0.67682124, 0.72091305, 0.96818829],
             [0.10955931, 0.59617498, 0.60177775, 0.8718779 , 0.95801931],
             [0.09933875, 0.20403836, 0.21766352, 0.3926468 , 0.48003049]])
```

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

```
[256]: array([[0.10955931, 0.59617498, 0.60177775, 0.95801931, 0.8718779 ],  
            [0.21766352, 0.09933875, 0.20403836, 0.3926468 , 0.48003049],  
            [0.54705689, 0.36136427, 0.73782371, 0.03135856, 0.59120535],  
            [0.70302585, 0.81114902, 0.38810458, 0.13382594, 0.62843572],  
            [0.96818829, 0.72091305, 0.19279555, 0.64519405, 0.67682124]])
```

```
[271]: np.linalg.lstsq(a, b, rcond=None)
```

```
[271]: (array([[ -0.02470314, -0.99426878,  0.24219306, -1.14861772, -0.45412453],  
            [-1.57705109, -0.14924059,  0.45581515, -0.19976327, -0.1638319 ],  
            [-1.46953047, -1.97687497, -0.39631202, -2.63141169, -1.54497317],  
            [-0.27431161, -1.07540872,  0.03782807, -2.75632378, -1.24713453],  
            [ 3.20349588,  3.7034493 ,  0.33499671,  5.27929192,  3.32657953]]),  
array([], dtype=float64),  
5,  
array([2.65088822, 0.8711694 , 0.63173817, 0.3178289 , 0.11755287]))
```

```
[268]: from scipy import signal  
signal.resample(a, int(np.ceil(len(a)/3)))
```

```
[268]: array([[0.5360673 , 0.47297501, 0.43944106, 0.01933851, 0.53229089],  
            [0.48213024, 0.56260103, 0.41037492, 0.84507935, 0.76705739]])
```

```
[269]: np.unique(a)
```

```
[269]: array([0.03135856, 0.09933875, 0.10955931, 0.13382594, 0.19279555,  
            0.20403836, 0.21766352, 0.36136427, 0.38810458, 0.3926468 ,  
            0.48003049, 0.54705689, 0.59120535, 0.59617498, 0.60177775,  
            0.62843572, 0.64519405, 0.67682124, 0.70302585, 0.72091305,  
            0.73782371, 0.81114902, 0.8718779 , 0.95801931, 0.96818829])
```

```
[270]: a.squeeze()
```

```
[270]: array([[0.70302585, 0.81114902, 0.38810458, 0.13382594, 0.62843572],  
            [0.54705689, 0.36136427, 0.73782371, 0.03135856, 0.59120535],  
            [0.96818829, 0.72091305, 0.19279555, 0.64519405, 0.67682124],  
            [0.10955931, 0.59617498, 0.60177775, 0.95801931, 0.8718779 ],  
            [0.21766352, 0.09933875, 0.20403836, 0.3926468 , 0.48003049]])
```