Pure Python

Types

```
a = 2           # integer
b = 5.0         # float
c = 8.3e5       # exponential
d = 1.5 + 0.5j  # complex
e = 4 > 5       # boolean
f = 'word'      # string
```

Lists

```
a = ['red', 'blue', 'green']       # manually initialization
b = list(range(5))                 # initialize from iteratable
c = [nu**2 for nu in b]            # list comprehension
d = [nu**2 for nu in b if nu < 3]  # conditioned list comprehension
e = c[0]                           # access element
f = c[1:2]                         # access a slice of the list
g = ['re', 'bl'] + ['gr']          # list concatenation
h = ['re'] * 5                     # repeat a list
['re', 'bl'].index('re')           # returns index of 're'
're' in ['re', 'bl']               # true if 're' in list
sorted([3, 2, 1])                  # returns sorted list
```

Dictionaries

```
a = {'red': 'rouge', 'blue': 'bleu'}         # dictionary
b = a['red']                                 # translate item
c = [value for key, value in a.items()]      # loop through contents
d = a.get('yellow', 'no translation found')  # return default
```

Strings

```
a = 'red'                      # assignment
char = a[2]                    # access individual characters
'red ' + 'blue'                # string concatenation
'1, 2, three'.split(',')       # split string into list
'.'.join(['1', '2', 'three'])  # concatenate list into string
```

Operators

```
a = 2             # assignment
a += 1 (*=, /=)   # change and assign
3 + 2             # addition
3 / 2             # integer (python2) or float (python3) division
3 // 2            # integer division
3 * 2             # multiplication
3 ** 2            # exponent
3 % 2             # remainder
abs(a)            # absolute value
1 == 1            # equal
2 > 1             # larger
2 < 1             # smaller
1 != 2            # not equal
1 != 2 and 2 < 3  # logical AND
1 != 2 or 2 < 3   # logical OR
not 1 == 2        # logical NOT
'a' in b          # test if a is in b
a is b            # test if objects point to the same memory (id)
```

Control Flow

```
# if/elif/else
a, b = 1, 2
if a + b == 3:
    print('True')
elif a + b == 1:
    print('False')
else:
    print('?')

# for
a = ['red', 'blue', 'green']
for color in a:
    print(color)

# while
number = 1
while number < 10:
    print(number)
    number += 1

# break
number = 1
while True:
    print(number)
    number += 1
    if number > 10:
        break

# continue
for i in range(20):
    if i % 2 == 0:
        continue
    print(i)
```

Functions, Classes, Generators, Decorators

```
# Function groups code statements and possibly
# returns a derived value
def myfunc(a1, a2):
    return a1 + a2

x = myfunc(a1, a2)

# Class groups attributes (data)
# and associated methods (functions)
class Point(object):
    def __init__(self, x):
        self.x = x
    def __call__(self):
        print(self.x)

x = Point(3)

# Generator iterates without
# creating all values at ones
def firstn(n):
    num = 0
    while num < n:
        yield num
        num += 1

x = [i for i in firstn(10)]

# Decorator can be used to modify
# the behaviour of a function
class myDecorator(object):
    def __init__(self, f):
        self.f = f
    def __call__(self):
        print("call")
        self.f()

@myDecorator
def my_funct():
    print('func')

my_funct()
```

IPython

console

```
<object>?  # Information about the object
<object>.<TAB>  # tab completion

# measure runtime of a function:
%timeit range(1000)
100000 loops, best of 3: 7.76 us per loop

# run scripts and debug
%run
%run -d  # run in debug mode
%run -t  # measures execution time
%run -p  # runs a profiler
%debug  # jumps to the debugger after an exception

%pdb  # run debugger automatically on exception

# examine history
%history
%history ~1/1-5  # lines 1-5 of last session

# run shell commands
!make  # prefix command with "!"

# clean namespace
%reset
```

debugger

```
n               # execute next line
b 42            # set breakpoint in the main file at line 42
b myfile.py:42  # set breakpoint in 'myfile.py' at line 42
c               # continue execution
l               # show current position in the code
p data          # print the 'data' variable
pp data         # pretty print the 'data' variable
s               # step into subroutine
a               # print arguments that a function received
pp locals()     # show all variables in local scope
pp globals()    # show all variables in global scope
```

command line

```
ipython --pdb -- myscript.py argument1 --option1  # debug after exception
ipython -i -- myscript.py argument1 --option1     # console after finish
```

NumPy (`import numpy as np`)

array initialization

```
np.array([2, 3, 4])             # direct initialization
np.empty(20, dtype=np.float32)  # single precision array of size 20
np.zeros(200)                   # initialize 200 zeros
np.ones((3,3), dtype=np.int32)  # 3 x 3 integer matrix with ones
np.eye(200)                     # ones on the diagonal
np.zeros_like(a)                # array with zeros and the shape of a
np.linspace(0., 10., 100)       # 100 points from 0 to 10
np.arange(0, 100, 2)            # points from 0 to <100 with step 2
np.logspace(-5, 2, 100)         # 100 log-spaced from 1e-5 -> 1e2
np.copy(a)                      # copy array to new memory
```

indexing

```
a = np.arange(100)          # initialization with 0 - 99
a[:3] = 0                   # set the first three indices to zero
a[2:5] = 1                  # set indices 2-4 to 1
a[start:stop:step]          # general form of indexing/slicing
a[None, :]                  # transform to column vector
a[[1, 1, 3, 8]]             # return array with values of the indices
a = a.reshape(10, 10)       # transform to 10 x 10 matrix
a.T                         # return transposed view
b = np.transpose(a, (1, 0)) # transpose array to new axis order
a[a < 2]                    # values with elementwise condition
```

array properties and operations

```
a.shape                # a tuple with the lengths of each axis
len(a)                 # length of axis 0
a.ndim                 # number of dimensions (axes)
a.sort(axis=1)         # sort array along axis
a.flatten()            # collapse array to one dimension
a.conj()               # return complex conjugate
a.astype(np.int16)     # cast to integer
np.argmax(a, axis=1)   # return index of maximum along a given axis
np.cumsum(a)           # return cumulative sum
np.any(a)              # True if any element is True
np.all(a)              # True if all elements are True
np.argsort(a, axis=1)  # return sorted index array along axis
```

boolean arrays

```
a < 2                     # returns array with boolean values
(a < 2) & (b > 10)        # elementwise logical and
(a < 2) | (b > 10)        # elementwise logical or
~a                        # invert boolean array
```

elementwise operations and math functions

```
a * 5              # multiplication with scalar
a + 5              # addition with scalar
a + b              # addition with array b
a / b              # division with b (np.NaN for division by zero)
np.exp(a)          # exponential (complex and real)
np.power(a, b)     # a to the power b
np.sin(a)          # sine
np.cos(a)          # cosine
np.arctan2(a, b)   # arctan(a/b)
np.arcsin(a)       # arcsin
np.radians(a)      # degrees to radians
np.degrees(a)      # radians to degrees
np.var(a)          # variance of array
np.std(a, axis=1)  # standard deviation
```

inner / outer products

```
np.dot(a, b)                        # inner product: a_mi b_in
np.einsum('ij,kj->ik', a, b)        # einstein summation convention
np.sum(a, axis=1)                   # sum over axis 1
np.abs(a)                           # return absolute values
a[None, :] + b[:, None]             # outer sum
a[None, :] * b[:, None]             # outer product
np.outer(a, b)                      # outer product
np.sum(a * a.T)                     # matrix norm
```

reading/ writing files

```
np.fromfile(fname/fobject, dtype=np.float32, count=5)  # binary data from file
np.loadtxt(fname/fobject, skiprows=2, delimiter=',')   # ascii data from file
np.savetxt(fname/fobject, array, fmt='%.5f')           # write ascii data
np.tofile(fname/fobject)                               # write (C) binary data
```

interpolation, integration, optimization

```
np.trapz(a, x=x, axis=1)  # integrate along axis 1
np.interp(x, xp, yp)      # interpolate function xp, yp at points x
np.linalg.lstsq(a, b)     # solve a x = b in least square sense
```

fft

```
np.fft.fft(a)                # complex fourier transform of a
f = np.fft.fftfreq(len(a))   # fft frequencies
np.fft.fftshift(f)           # shifts zero frequency to the middle
np.fft.rfft(a)               # real fourier transform of a
np.fft.rfftfreq(len(a))      # real fft frequencies
```

rounding

```
np.ceil(a)   # rounds to nearest upper int
np.floor(a)  # rounds to nearest lower int
np.round(a)  # rounds to neares int
```

random variables

```
from np.random import normal, seed, rand, uniform, randint
normal(loc=0, scale=2, size=100)  # 100 normal distributed
seed(23032)                       # resets the seed value
rand(200)                         # 200 random numbers in [0, 1)
uniform(1, 30, 200)               # 200 random numbers in [1, 30)
randint(1, 16, 300)               # 300 random integers in [1, 16)
```

Matplotlib (`import matplotlib.pyplot as plt`)

figures and axes

```
fig = plt.figure(figsize=(5, 2))  # initialize figure
ax = fig.add_subplot(3, 2, 2)     # add second subplot in a 3 x 2 grid
fig, axes = plt.subplots(5, 2, figsize=(5, 5)) # fig and 5 x 2 nparray of axes
ax = fig.add_axes([left, bottom, width, height]) # add custom axis
```

figures and axes properties

```
fig.suptitle('title')            # big figure title
fig.subplots_adjust(bottom=0.1, right=0.8, top=0.9, wspace=0.2,
                    hspace=0.5)  # adjust subplot positions
fig.tight_layout(pad=0.1, h_pad=0.5, w_pad=0.5,
                 rect=None)      # adjust subplots to fit into fig
ax.set_xlabel('xbla')            # set xlabel
ax.set_ylabel('ybla')            # set ylabel
ax.set_xlim(1, 2)                # sets x limits
ax.set_ylim(3, 4)                # sets y limits
ax.set_title('blabla')           # sets the axis title
ax.set(xlabel='bla')             # set multiple parameters at once
ax.legend(loc='upper center')    # activate legend
ax.grid(True, which='both')      # activate grid
bbox = ax.get_position()         # returns the axes bounding box
bbox.x0 + bbox.width             # bounding box parameters
```

plotting routines

```
ax.plot(x,y, '-o', c='red', lw=2, label='bla')  # plots a line
ax.scatter(x,y, s=20, c=color)                  # scatter plot
ax.pcolormesh(xx, yy, zz, shading='gouraud')    # fast colormesh
ax.colormesh(xx, yy, zz, norm=norm)             # slower colormesh
ax.contour(xx, yy, zz, cmap='jet')              # contour lines
ax.contourf(xx, yy, zz, vmin=2, vmax=4)         # filled contours
n, bins, patch = ax.hist(x, 50)                 # histogram
ax.imshow(matrix, origin='lower',
          extent=(x1, x2, y1, y2))              # show image
ax.specgram(y, FS=0.1, noverlap=128,
            scale='linear')                     # plot a spectrogram
```

Scipy (`import scipy as sci`)

interpolation

```
from scipy.ndimage import map_coordinates     # interpolates data
pts_new = map_coordinates(data, float_indices,  # at index positions
                          order=3)
```

Integration

```
from scipy.integrate import quad      # definite integral of python
value = quad(func, low_lim, up_lim)   # function/method
```