DEDA Digital Economy & Decision Analytics

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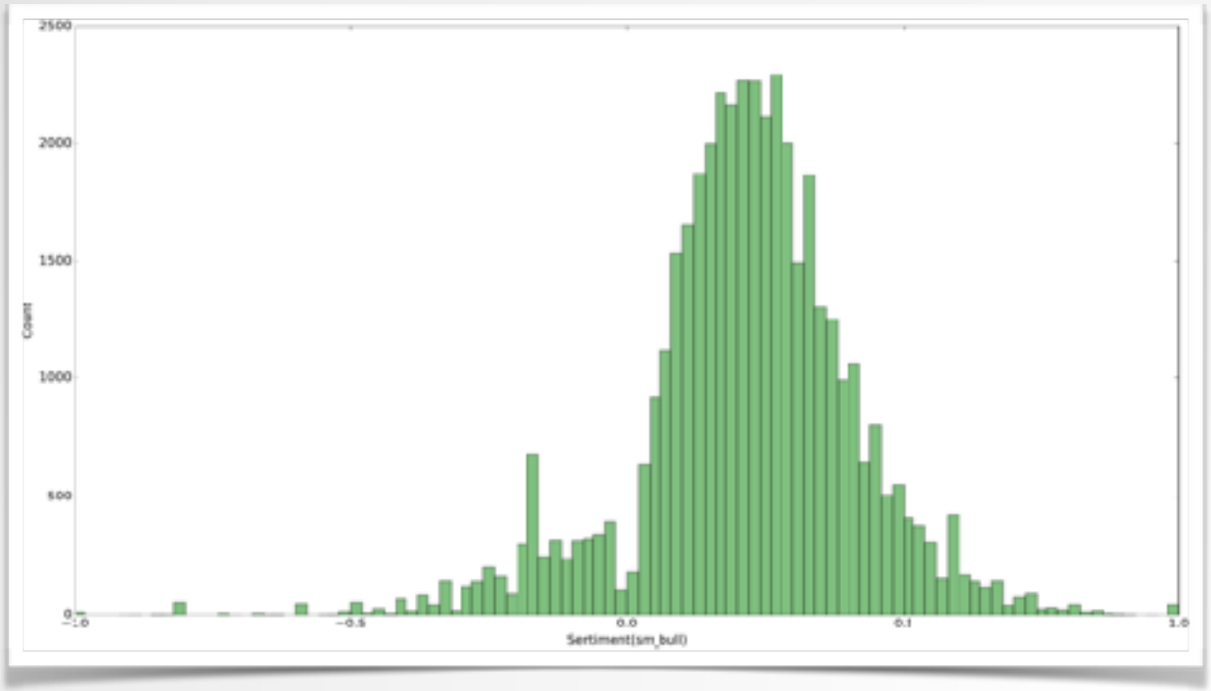
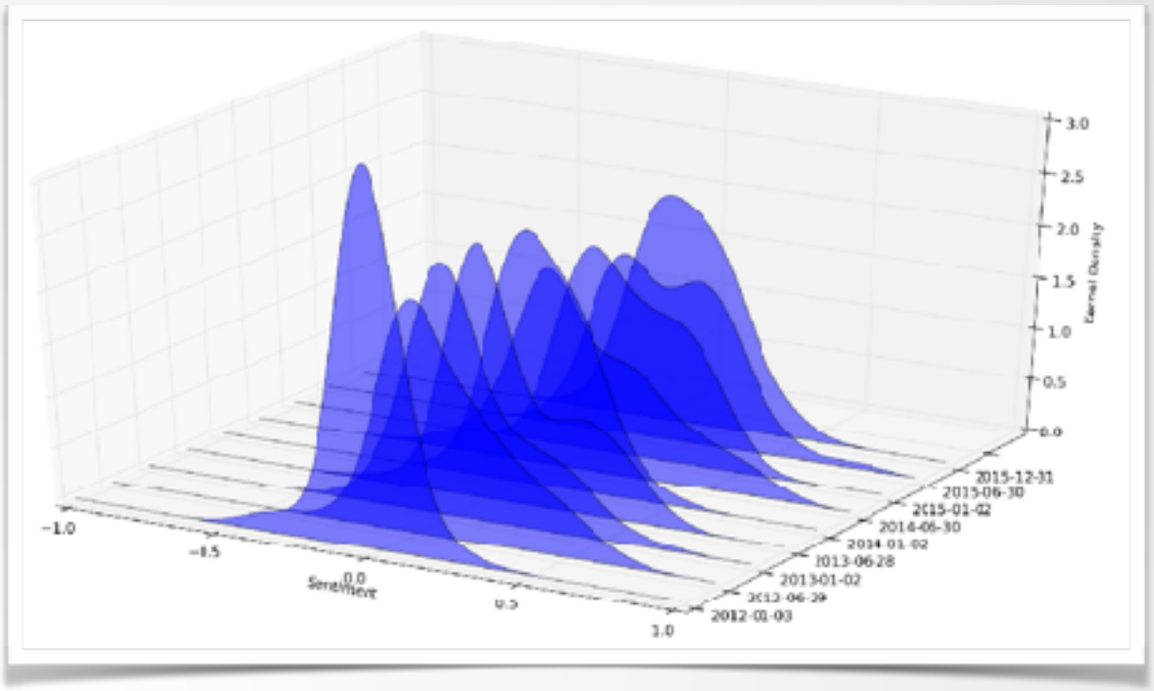
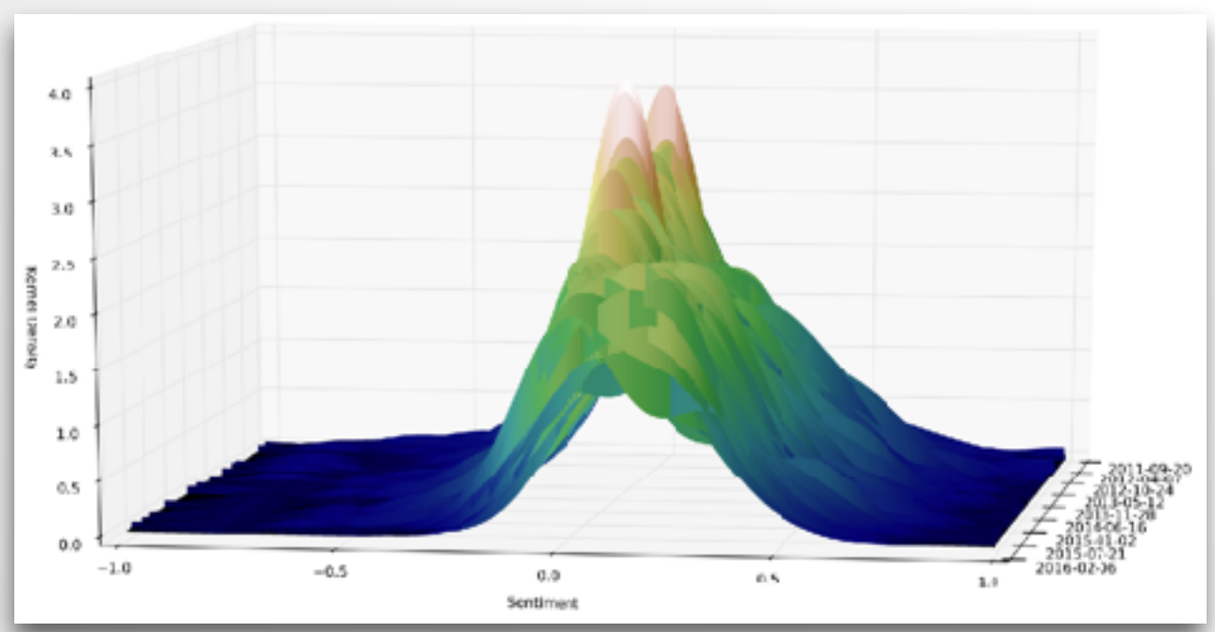
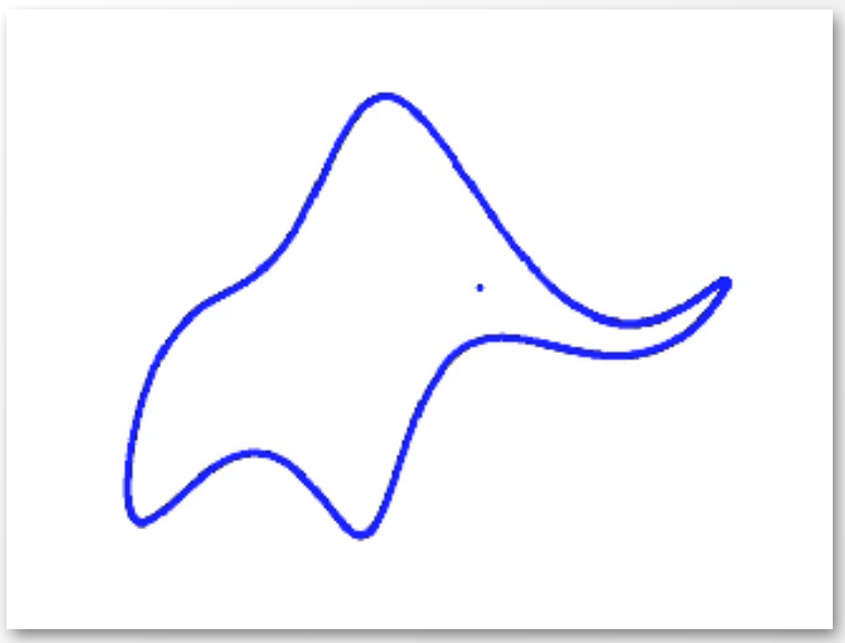
Smart Data Analytics









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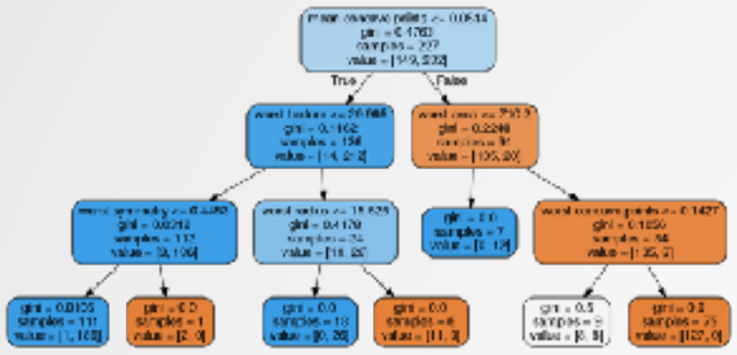

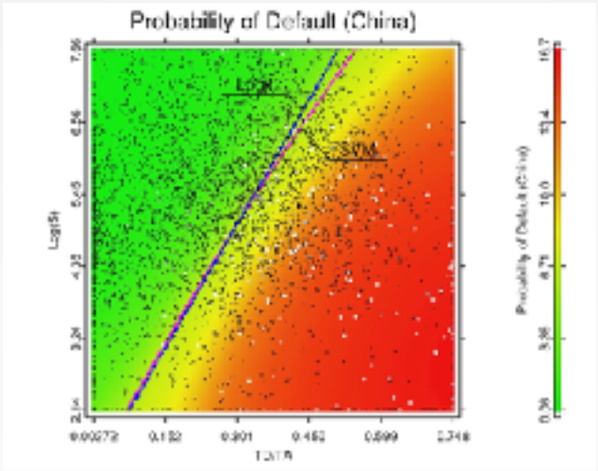

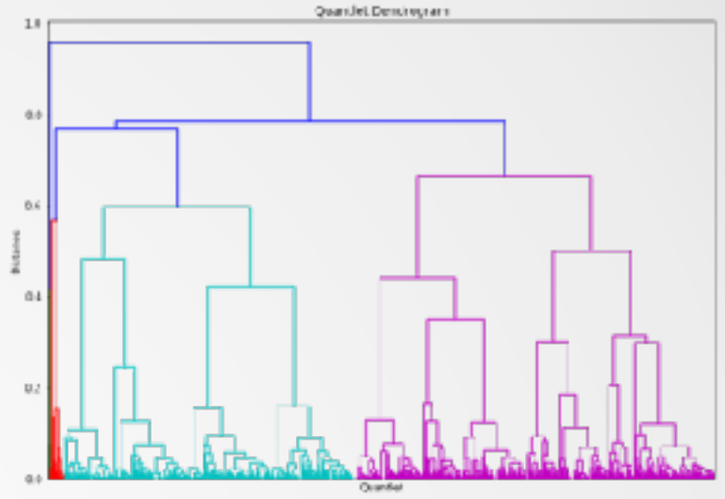

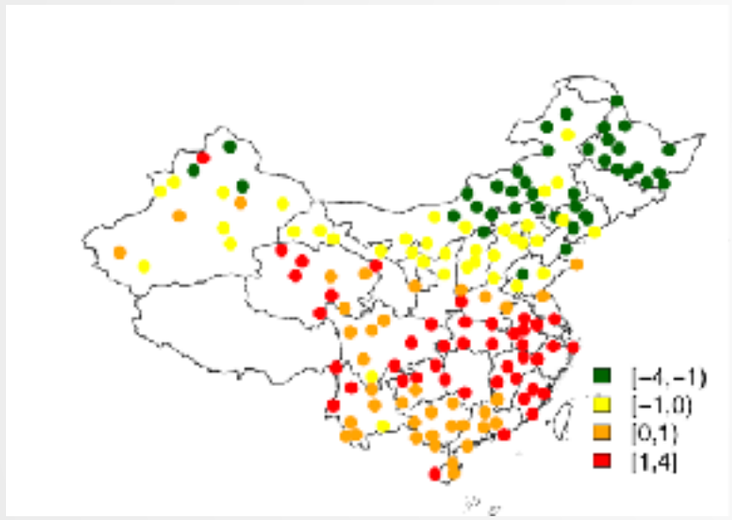

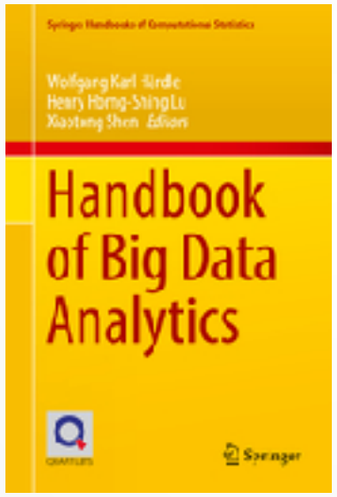

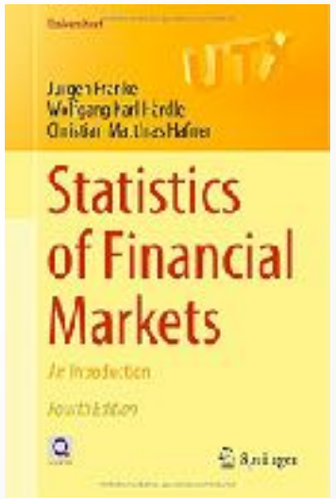

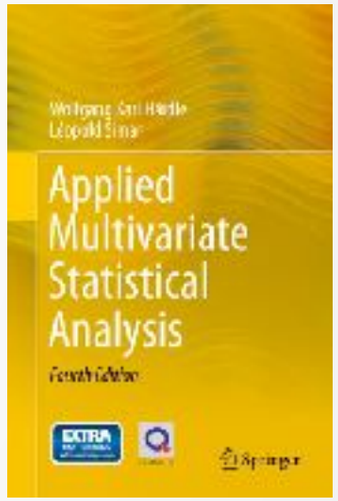

DT Decision Tree, RF Random Forest, Bagging, SVM Support Vector Machine, Clustering, Smoothing, ML Machine Learning, Variable Selection, Q Quantlets, LDA Latent Dirichlet Analysis, DTM Dynamic Topic Modeling, P2P Peer to Peer lending, PCA Principle Component Analysis, Spectral Clustering, CRIX Crypto currency IndeX, Sentiment Analysis, Web Scraping, Opinion Mining

Digital Economy & Decision Analytics

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同时兼任IRTG项目的总负责人
厦门大学的外籍专家教授

DEDA - outline

1. **Introduction of Python**

   Python Installation, IDE and Basic Syntax

   Data Structure and Commonly Used Operations

2. **Webpage Scraping in Python**

   Introduction of Webpage Scraping in Python

   Webpage Scraping Framework in Python

3. **Statistics and Finance in Python**

   Basic Statistics and Visualization in Python

   Python in Finance

4. **Machine Learning Methods**

   Introduction to ML Machine Learning

   Statistics and Finance

DEDA Schedule and Course Outline

C YH Chen, WK Härdle

1. How to install and run Python. Only MAC instructions are shown.
2. How to make an elephant with 4 params and wiggle its trunk
3. Note that all code is on QuantNet www.quantlet.de
4. https://github.com/QuantLet/DEDA_Class_2017
5. https://github.com/QuantLet/DEDA_Class_2017/tree/master/DEDA_Class_2017_Python_Introduction
6. Unit_2 : Packages, etc…

Python Programming Reference Books

[1] Charles Russell Severance. **Python for everyone**[M]. CreateSpace Independent Publishing Platform (2016)
Free PDF: https://www.py4e.com/book

[2] Shaw Z A. **Learn Python 3 the Hard Way** [J]. Addison-Wesley Professional (2017)

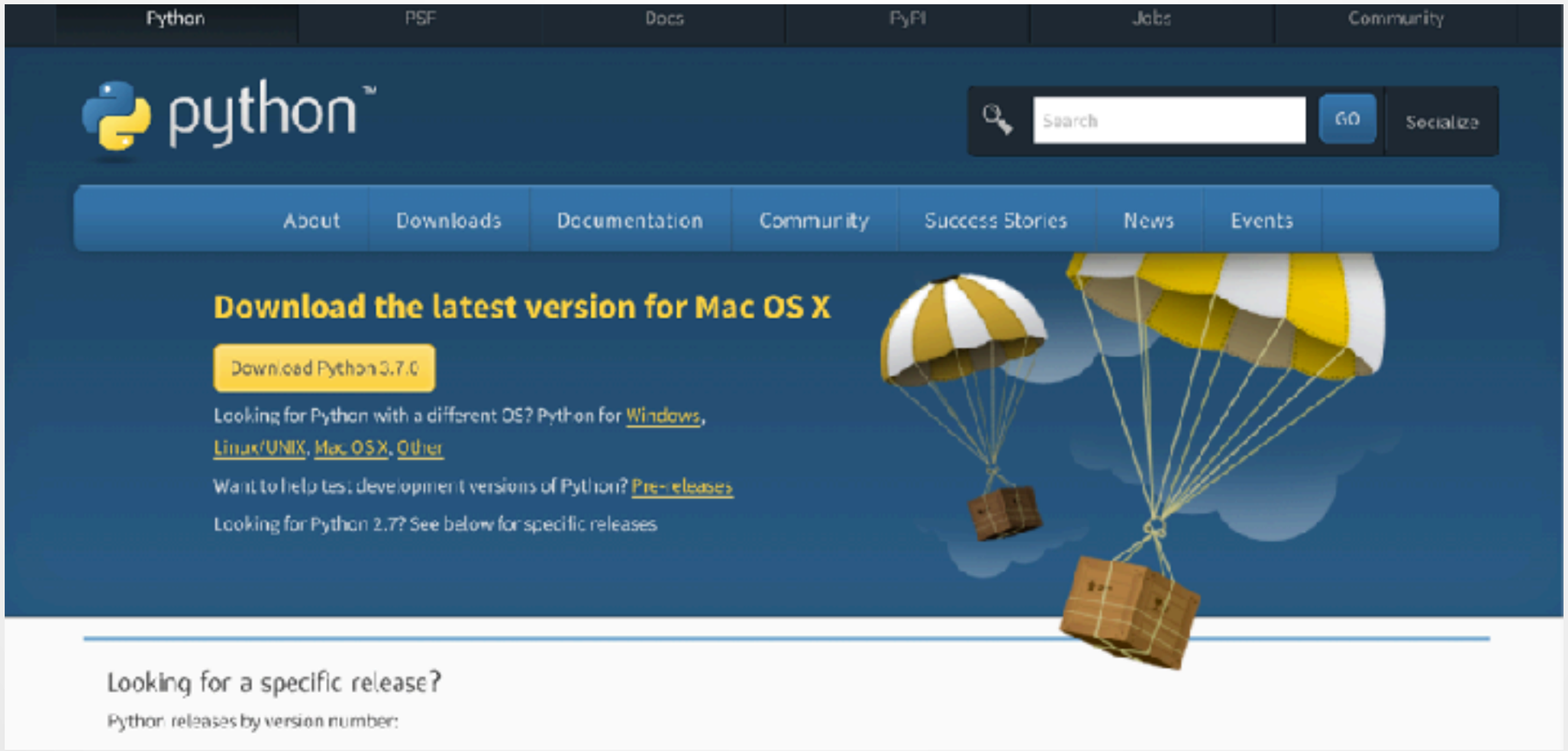
[3] McKinney W. **Python for data analysis: Data wrangling with Pandas, NumPy, and IPython**[M]. O'Reilly Media, Inc. (2012)

[4] Hilpisch Y. **Python for Finance: Analyze Big Financial Data**[M]. O'Reilly Media, Inc., (2014)

[5] Jones B., Beazley D. **Python Cookbook, 3rd Edition**[M]. O'Reilly Media, Inc., (2013)

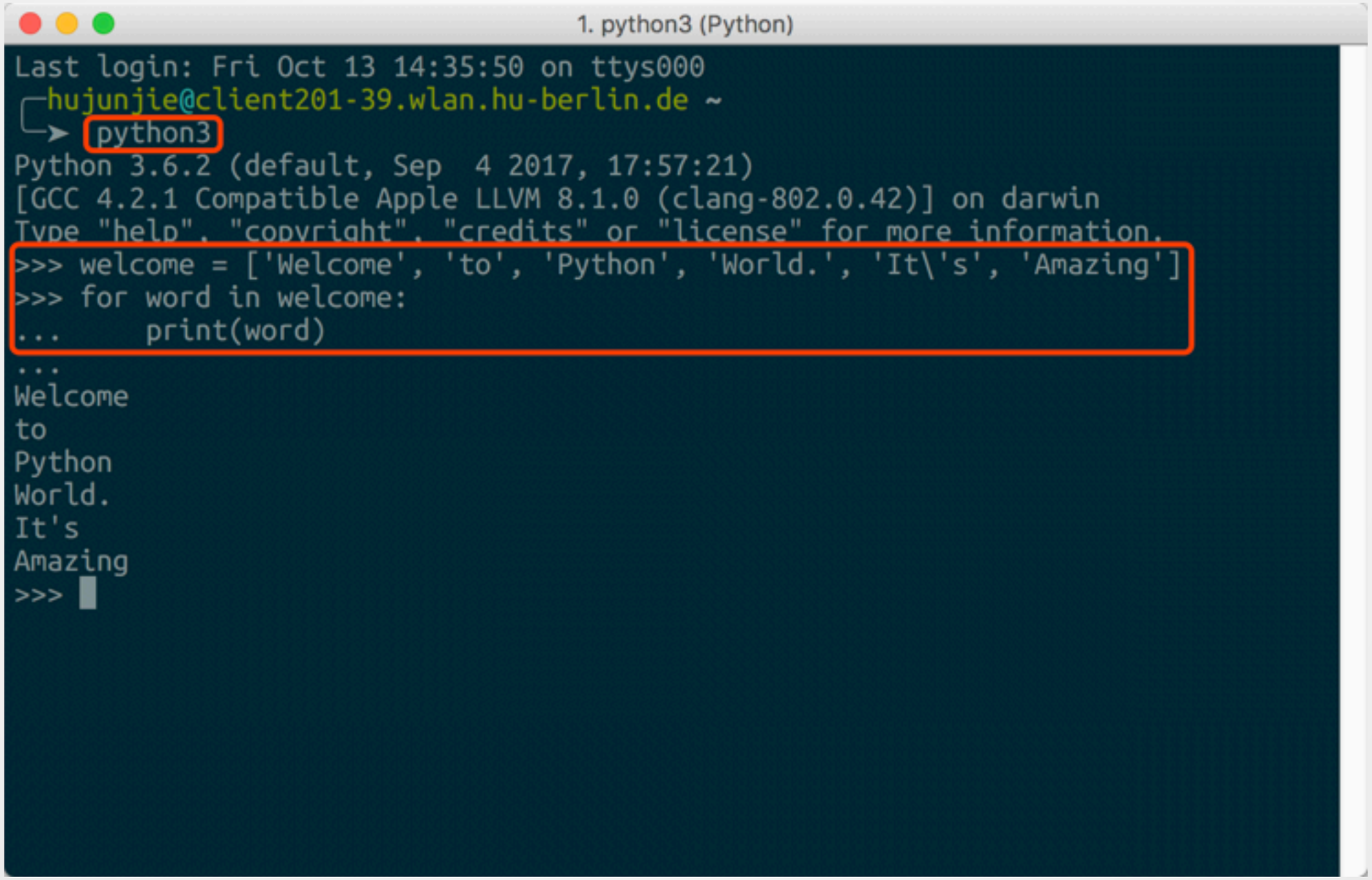
Python Installation and Environment

Open the Python official web site and download python install package:
https://www.python.org/
Python 3 is recommended,
Python 2 is retiring soon (Support stops 1st Jan. 2020), download Python 3.7 (or higher version) if not for special reason. Alternatively download Anaconda containing Python 3 already.



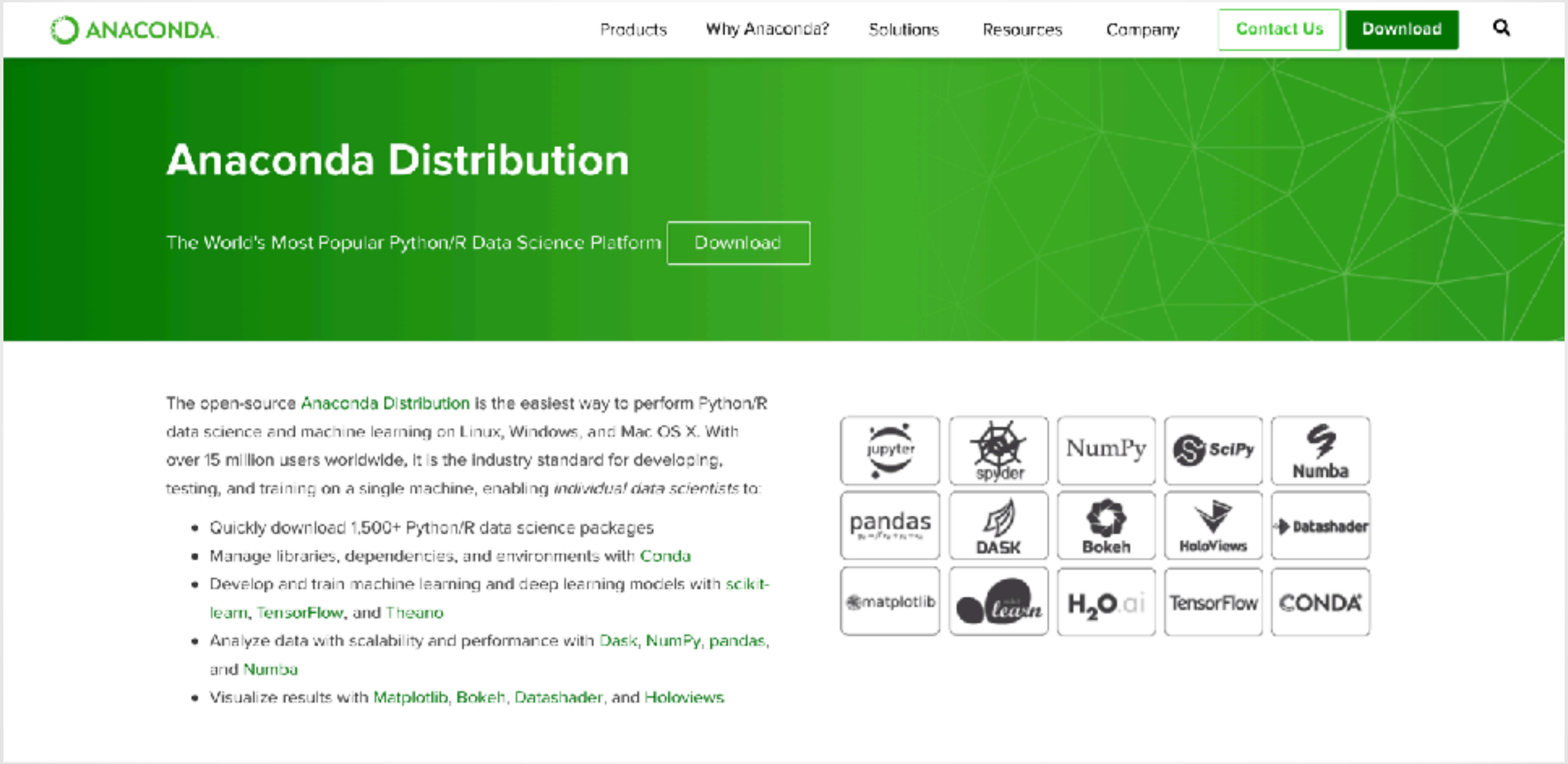
Python Installation and Environment

After installation, using "terminal" (mac os) / "cmd" (windows) to enter the python interactive interface. Simply typing "python3".



Anaconda - A Data Science Platform

Download Anaconda from: https://www.anaconda.com/download/

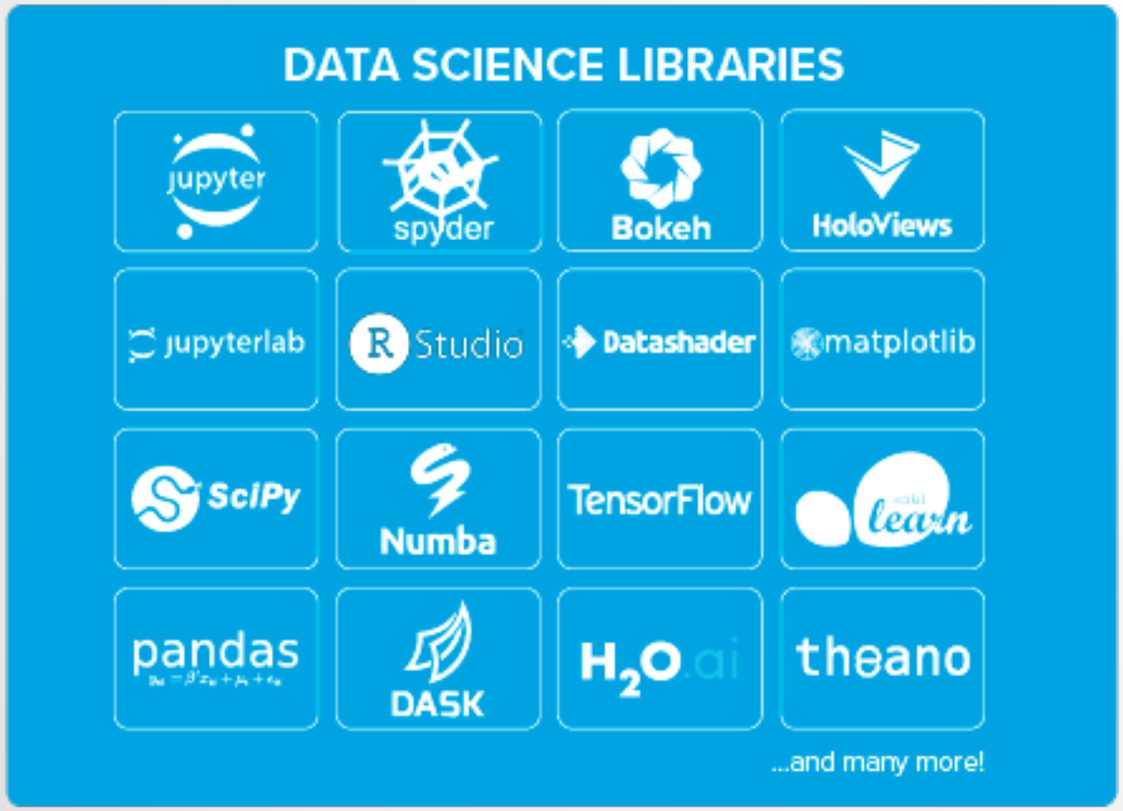


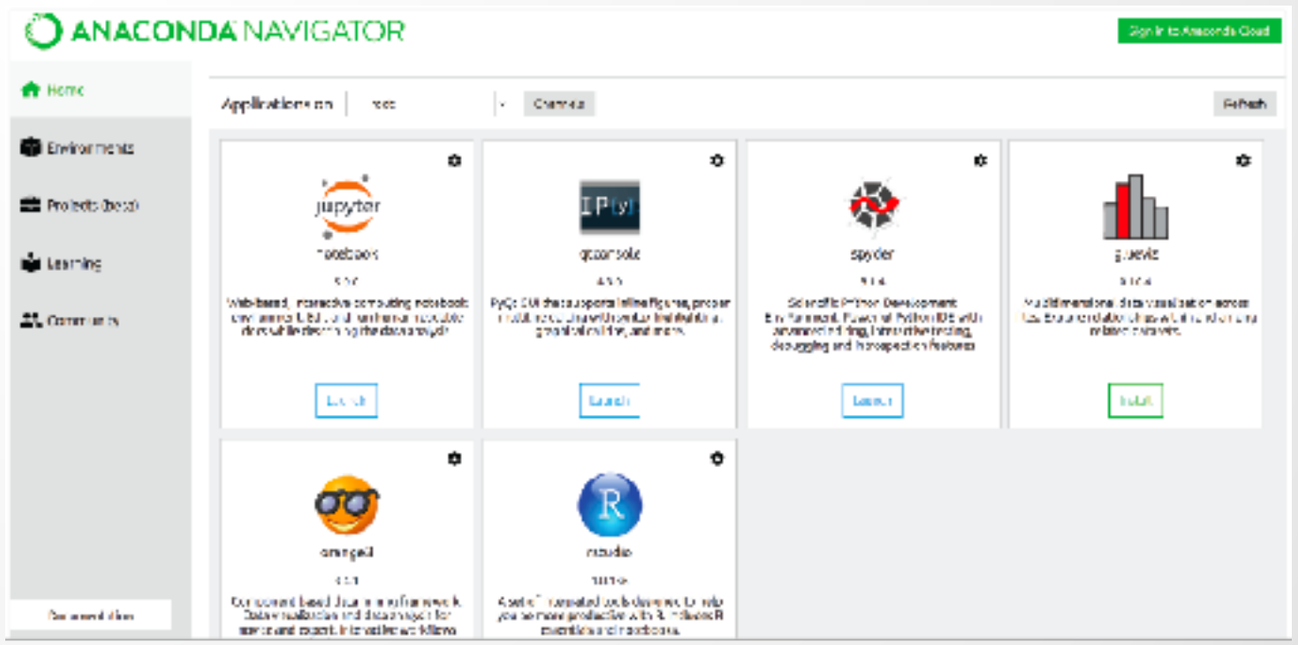
Anaconda - A Data Science Platform

Download Anaconda from: https://www.anaconda.com/download/

Anaconda is a package that integrates python environment, IDEs (spyder, jupyter, R studio), package management system (conda) and a lot of useful packages.

In the nutshell, Anaconda is an open-to-use platform for data science. It makes people easily access python.





More Recommendations

- Customizing coding environment:
  - IDEs:

    PyCharm, Visual Studio

  - Package & environment management:

    pip, Virtualenv, pipenv, pyenv

  - Version Control:

    Git (GitHub, GitLab)

  - More tools for smoother coding:

    brew (for mac), Sublime3, Atom, Vim, Emacs and etc. *

** Some tools may have sharp learning curve.*

Basic Syntax _ numeric

```
"""
Python provides a straight way for numerical operations
Try the basics:
+, -, *, /, %, **, //
"""


a = 5
b = 3
a *= 2  # 10
round(a / b, 4)  # 3.3333


c = '10'
d = '20'
e = c + d  # '1020'
f = int(c) + int(d)  # 30

"""
try comparison operations:
==, <, <=, >, >=, !=
"""
```

Try this cool link!

Basic Syntax _ comparison

```
"""
Python provides a straight way for numerical operations
Try comparison operations
==,<,<=,>,>=,!=
"""


a = 5
a == 5 # True

a <= 5 # True
a < 5 # False


a = 'A'
b = 'B'
a == b # False
a != b # True
```

Basic Syntax _ string

```
"""
String is a basic type in python, it's commonly used and very powerful
"""


welcome_list = ['Welcome', 'to', 'Python', 'World.', 'It\'s', 'Amazing']
# using back slash to escape the single quote.

# using for loop to iterate all elements in the list.
for word in welcome_list:
    print(word)


# a string is also an object, using the join method to connect all the words in the
list.
welcome_sentence = ' '.join(welcome_list)

# slicing string by indices. Check carefully how many characters you are slicing
welcome_sliced = welcome_sentence[0:10]
# try changing the indices to negative.
```

Basic Syntax _ string

```
"""
String is a basic type in python, it's commonly used and very powerful
"""


# see other methods of string object, like:
welcome_upper_case = welcome_sentence.upper()
# by using dir() function, or help() function; you may see all ops on the str object
dir(str)
# or a str instance
dir(welcome_upper_case)
# likewise,
help(str)

# formatting string
greeting = 'Hallo'
name = 'Jon'
# using format method, -> Hallo, JON. Welcome to Python World. It's amazing
welcome_jon = '{}, {}. '.format(greeting, name.upper()) + welcome_sentence
# using f string, you can write variable names inside the brackets, directly.
welcome_jon_f = f'{greeting}, {name.upper()}. '+ welcome_sentence
```

Basic Syntax _ list

```
"""
List is a versatile Python data type to group values.
Lists can contain different types, e.g. strings, numbers,
functions, lists, ...
"""
p = [2,3,5,7,11]
p # [2, 3, 5, 7, 11]

# indexing
p[0] # 2
p[-1] # 11

# sclicing
p[:2] # [2, 3]
p[-3:] # [5, 7, 11]

# appending
p.append(13) # [2, 3, 5, 7, 11, 13]
p.extend([17,19]) # [2, 3, 5, 7, 11, 13, 17, 19]

l = list('hallo') # ['h', 'a', 'l', 'l', 'o']
l.sort() # ['a', 'h', 'l', 'l', 'o']
```

Basic Syntax _ dictionary

```
"""
Dictionary is indexed by keys, in general strings.
"""
course = dict(name='DEDA', unit=0) # {'name': 'DEDA', 'unit': 0}
# alternative
course = {'name':'DEDA', 'unit':0} # {'name': 'DEDA', 'unit': 0}

# accessing
course['unit'] # 0
course['unit'] = 1


# get keys
course.keys() # ['name', 'unit']
course.values() # ['DEDA', 1]
# ATTENTION: Output type varies with version of Python: {'Python2.7': list,
'Python3.7': 'its own data type'}

# adding values
course.update({'lecturers':['Chen','Härdle']})
# {'lecturers': ['Chen', 'Härdle'], 'name': 'DEDA', 'unit': 1}
```

Basic Syntax _ if

```
"""
Control Flow Tools: if/elif/else
"""
x = 10
if x < 0:
    print('Negative value')
elif x == 0:
    print('Zero')
else:
    print('Positive value')
# Positive value

# Conditions can be combined or altered with: and, or, not, is, is not
# Comparision statements can be used
p = [2,3,5,7,11]
3 in p # True
3 in p and 4 in p # False
3 in p or 4 in p # True
if x is not None:
    print('Value is not None’)
# Alternative
if not x is None:
    print('Value x is not None')
```

Basic Syntax _ for loop

```
"""
For Loop can iterate over all iterables.
"""
l = list([1,2,3,4,5])
for i in l:
    print(i*2, end=' ')
# 2 4 6 8 10

for i in range(6):
    if i == 3:
        continue
    print(i*2, end=' ')
# 0 2 4 8 10

for i in 'DEDA':
    print(i, end=' ')
# D E D A

d = dict(a=1,b=2)
for k,v in d.items():
    print('{} has value {}'.format(k,v))
# a has value 1
# b has value 2
```

Basic Syntax _ while loop

```
"""
While loop
There is no Do-While-Loop
"""
# Fibonacci series: sum of two preceding numbers defines next number
from __future__ import print_function
a, b = 0, 1
while b < 100:
    print(b, end=' ')
    a,b = b, b+a
# 1 1 2 3 5 8 13 21 34 55 89
# ATTENTION: Make sure not to have infinite loop (loop with tautology in condition)

# Do While Loop
fib = [0,1]
while True:
    fib.append(sum(fib[-2:]))
    if fib[-1] > 100:
        break
fib # [0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144]
```

Basic Syntax _ function

```
"""
Function definition
"""
def square_numeric(x):
    """ Squares numeric x"""
    return x**2

def square_iterable(x):
    """ Squares numerics in iterable x"""
    ret = []
    for i in x:
        ret.append(square_numeric(i))
    return ret

def square_iterabel_short(x):
    """ Squares numerics in iterable x"""
    return [square_numeric(i) for i in x]

x = [1,2,3,4,5]
square_iterable(x)  # [1, 4, 9, 16, 25]
square_iterabel_short(x) # [1, 4, 9, 16, 25]
```

Fitting an elephant with 4 params

- *"With four parameters I can fit an elephant, and with five I can make him wiggle his trunk"*

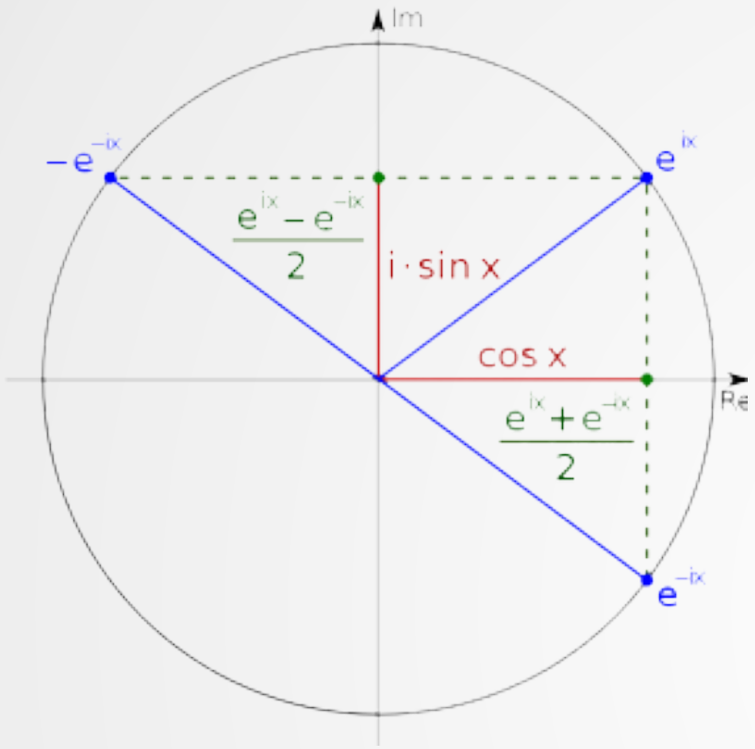
  John von Neumann (1903-1957) on BBI:

- Complex models with many params fits any data set. JvN employed Fourier coordinate expansion to describe a 2-dim contour in the form of an elephant.

- The Fourier expansion has many applications in engineering, finance although in the beginning it was called "a monster" by Henri Poincaré

Fitting Elephant

Complex Numbers



$$(a,b)(d,c) = (ac - bd, ad + bc)$$

$$\bar{z} = a - ib \qquad |z| = \sqrt{a^2 + b^2}$$

$$z + \bar{z} = 2\,\mathrm{Re}\,z$$

$$\mathrm{Im}\,z = \frac{z - \bar{z}}{2i}$$

There is NO order in C, i.e.

~~$z > w, z < w$~~ ~~$-i > 0$~~ ~~$i > 0$~~

$$(cos\phi + isin\phi)^n = cosn\phi + isinn\phi$$

$$cos\phi = \frac{e^{i\phi} + e^{-i\phi}}{2} \quad sin\phi = \frac{e^{i\phi} - e^{-i\phi}}{2i}$$

The Fourier coordinate expansion

- The Fourier expansion is the opposite of the FFT
- Note that we do not have the complex unit j anymore!
- The coefficients come from the four input parameters

$$p_1 = 50 - 30j \qquad C_x[1] = p_1.\text{Re} \cdot j = 50j \qquad C_y[1] = p_4.\text{Im} + p_1.\text{Im} \cdot j = -60 - 30j$$

$$p_2 = 18 - 8j \qquad C_x[2] = p_2.\text{Re} \cdot j = 18j \qquad C_y[2] = p_2.\text{Im} \cdot j = 8j$$

$$p_3 = 12 - 10j \qquad C_x[3] = p_3.\text{Re} = 12 \qquad C_y[3] = p_3.\text{Im} \cdot j = -10j$$

$$p_4 = -14 - 60j \qquad C_x[2] = p_4.\text{Re} = -14$$

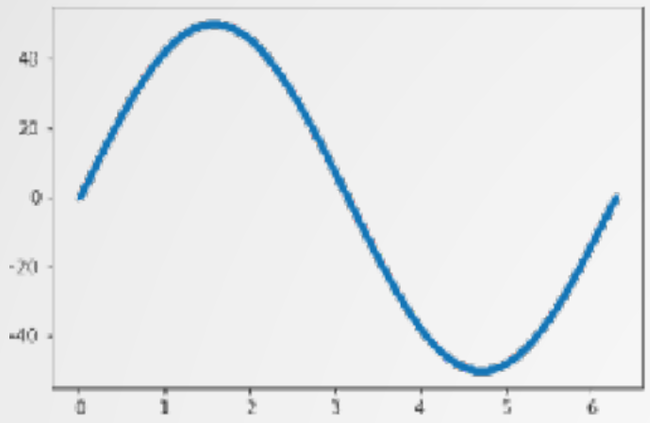
$$A = C.\text{Re}\,, \quad B = C.\text{Im}$$

$$f_x(t) = \sum_{k=0}^{5} \left(A_x[k]cos\left(kt\right) + B_x[k]sin(kt) \right) = 50sin(t) + 18sin(2t) + 12cos(3t) - 14cos(5t)$$

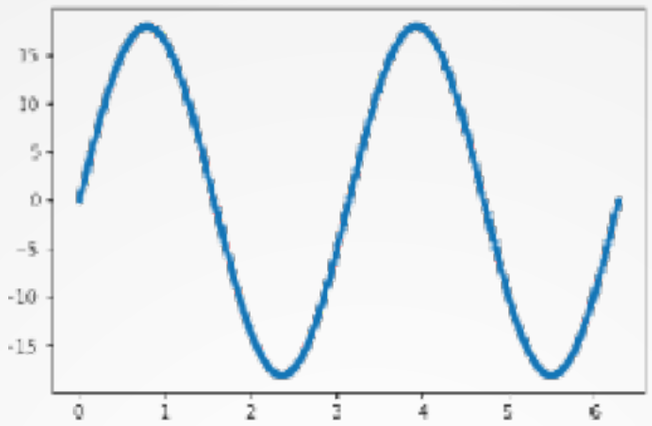
$$f_y(t) = \sum_{k=0}^{5} \left(A_y[k]cos\left(kt\right) + B_y[k]sin(kt) \right) = -60cos(t) - 30sin(t) + 8sin(2t) - 10sin(3t)$$

The elephant x-coordinate

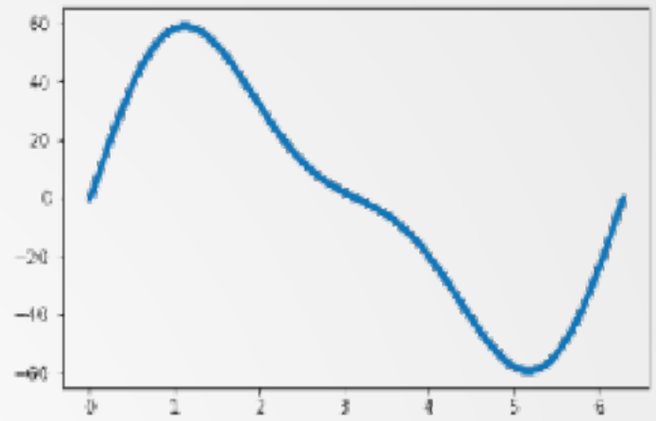
$50sin(t)$



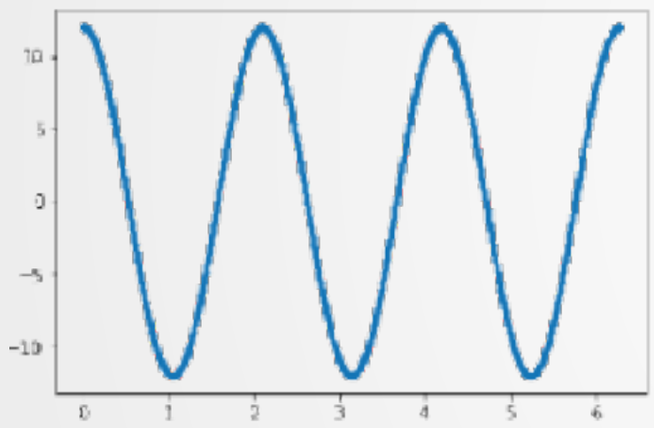
$18sin(t)$



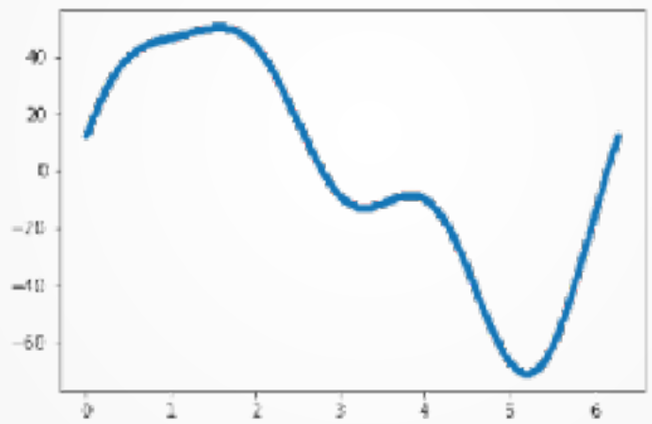
$50sin(t) + 18sin(2t)$



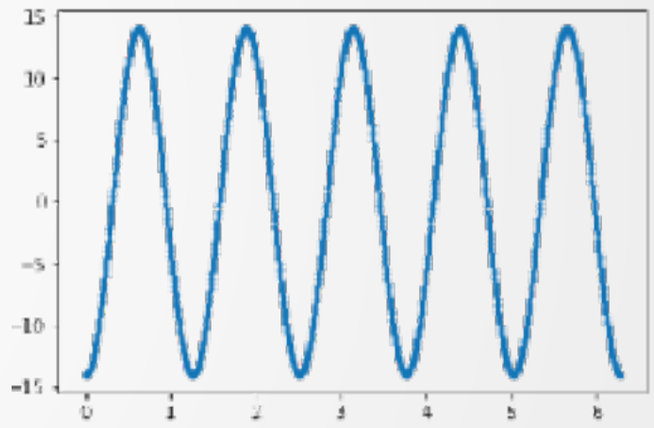
$12cos(3t)$



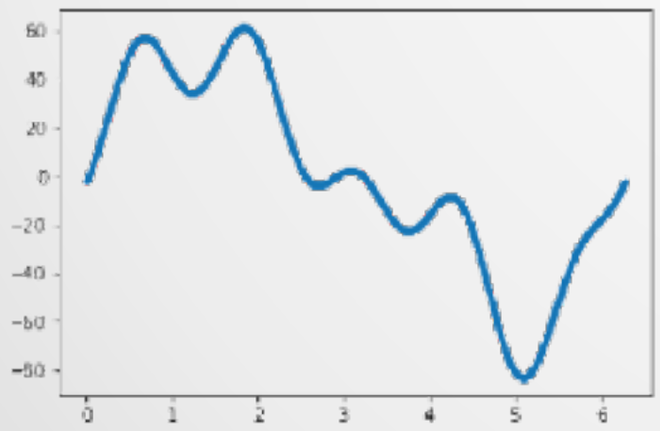
$50sin(t) + 18sin(2t) + 12cos(3t)$

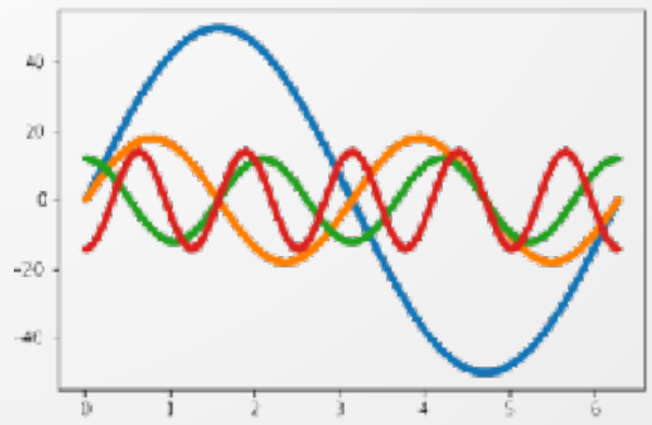


$-14cos(5t)$



$50sin(t) + 18sin(2t) + 12cos(3t) - 14cos(5t)$





50 sin(t)

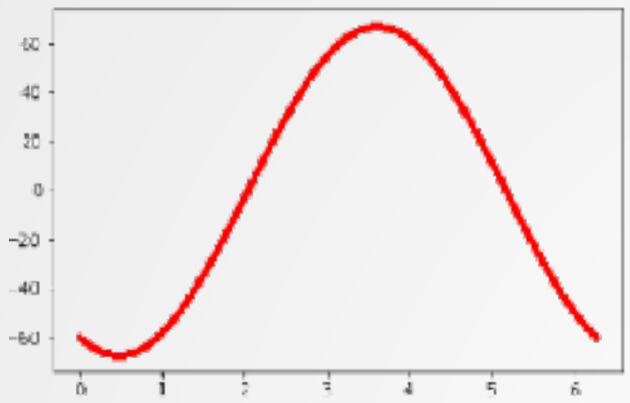
18 sin(2t)

12 cos(3t)

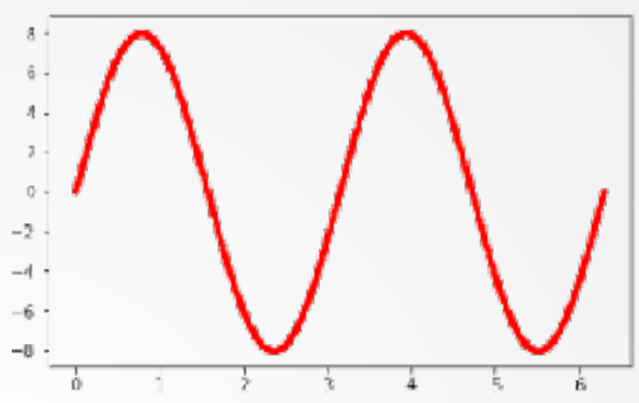
-14 cos(5t)

The elephant y-coordinate

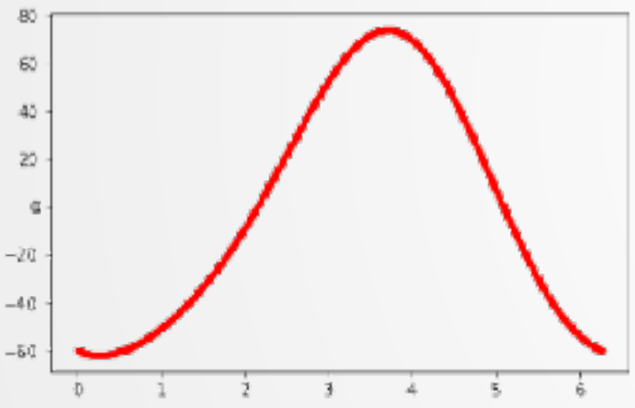
$-60cos(t) - 30sin(t)$



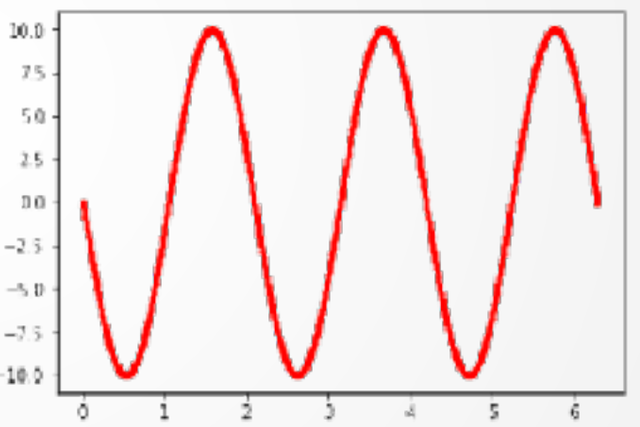
$8sin(2t)$



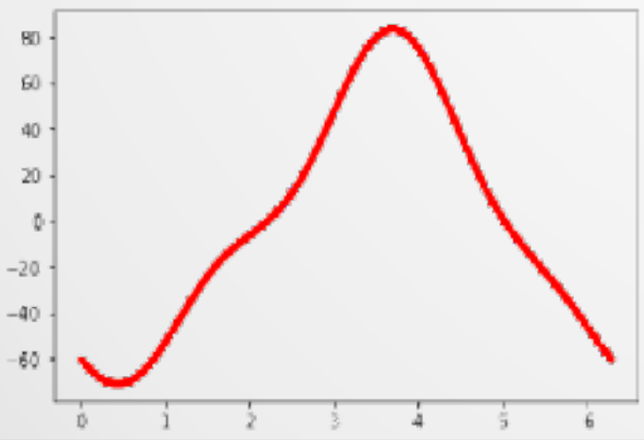
$-60cos(t) - 30sin(t) + 8sin(2t)$

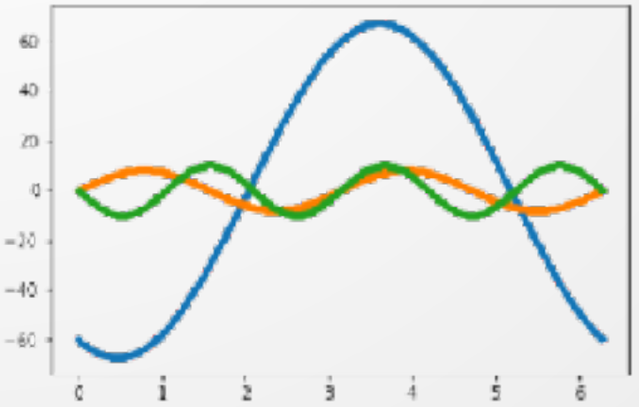


$-10sin(3t)$



$-60cos(t) - 30sin(t) + 8sin(2t) - 10sin(3t)$

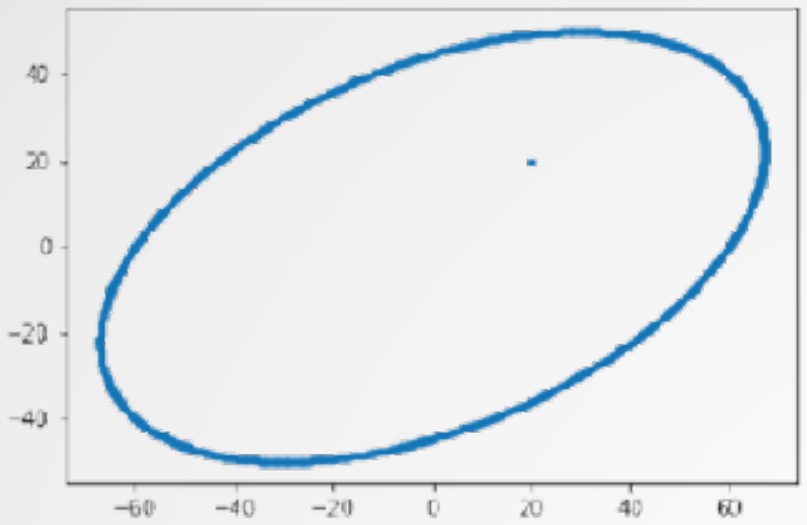




-60 cos(t) - 30 sin(t)

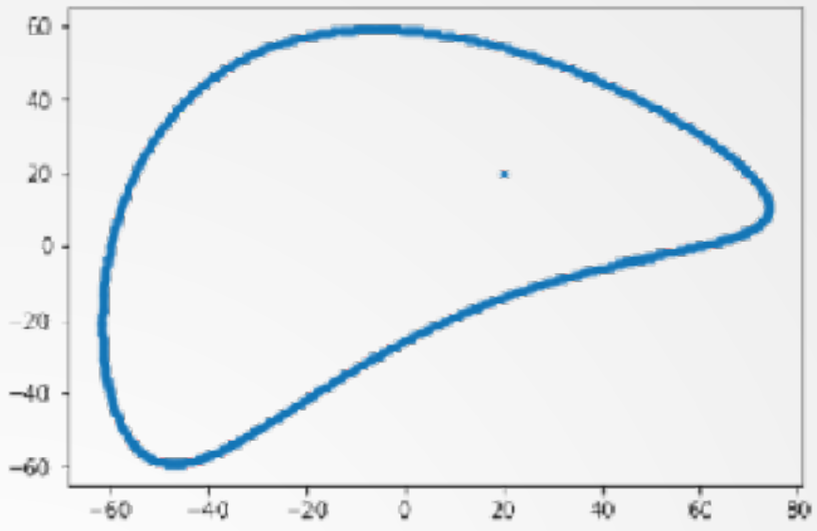
-10 sin(3t)

8 sin(2t)



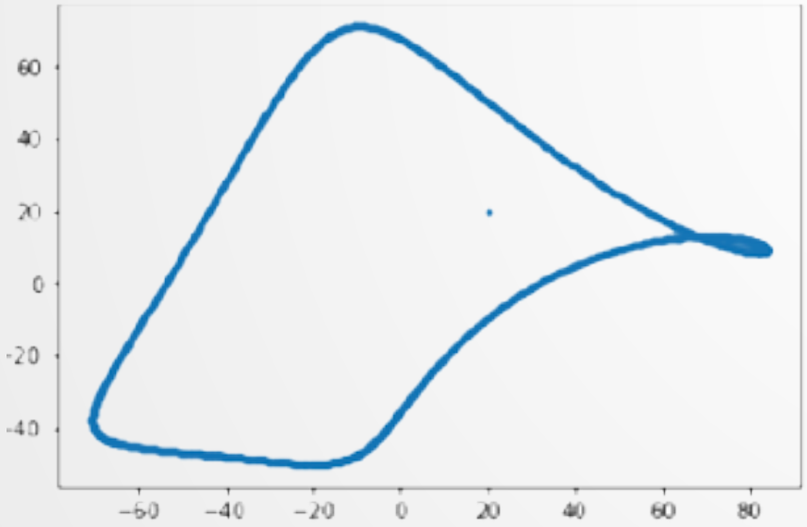
$$f(t) = \sum_{k=0}^{1} \Big(A[k]cos\left(kt\right) + B[k]sin(kt) \Big)$$

$$\big(50sin(t), -60cos(t) - 30sin(t)\big)$$



$$f(t) = \sum_{k=0}^{2} \Big(A[k]cos\left(kt\right) + B[k]sin(kt) \Big)$$

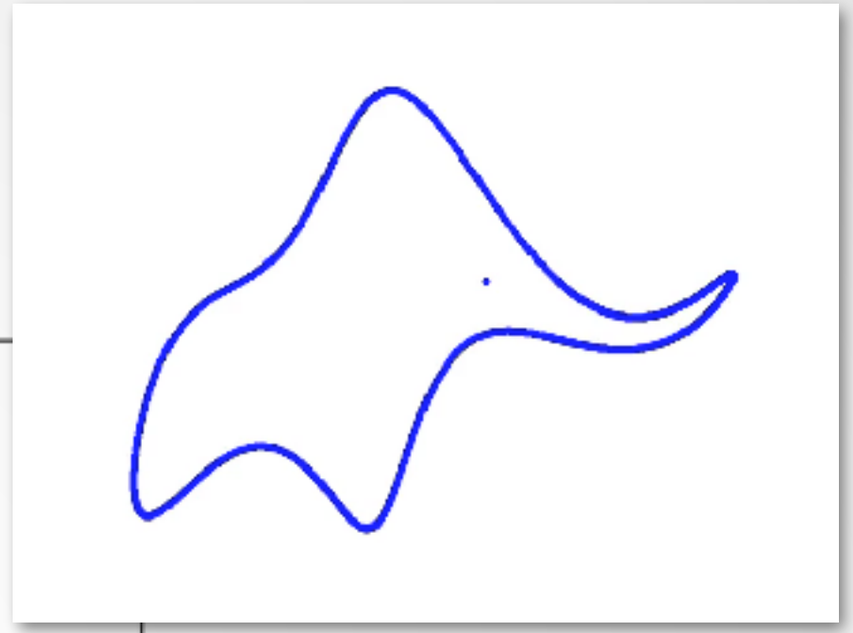
$$\big(50sin(t) + 18sin(2t), -60cos(t) - 30sin(t) + 8sin(2t)\big)$$

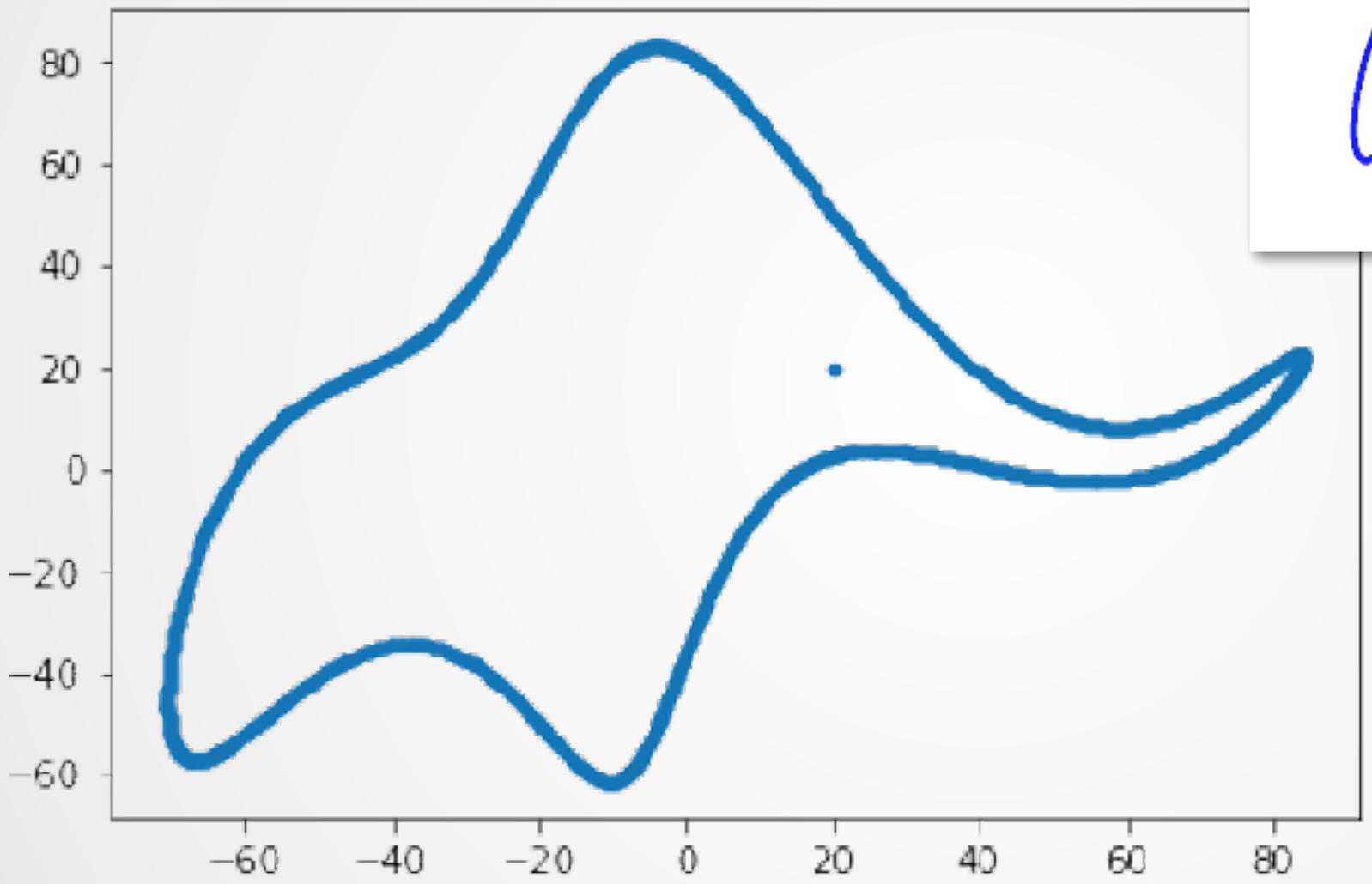


$$f(t) = \sum_{k=0}^{3} \Big(A[k]cos\left(kt\right) + B[k]sin(kt) \Big)$$

$$\big(50sin(t) + 18sin(2t) + 12cos(3t), -60cos(t) - 30sin(t) + 8sin(2t) - 10sin(3t)\big)$$

Finally the elephant





$$f(t) = \sum_{k=0}^{5} \Big(A[k]cos\left(kt\right) + B[k]sin(kt) \Big)$$

$$\big(50sin(t) + 18sin(2t) + 12cos(3t) - 14cos(5t), -60cos(t) - 30sin(t) + 8sin(2t) - 10sin(3t)\big)$$

Using complex numbers allows low number of params

```
from numpy import append, cos, linspace, pi, sin, zeros

# elephant parameters PLEASE NOTE IN SPYDER YOU SHOULD DISABLE THE ACTIVE SUPPORT in PREFs
parameters = [50 - 30j, 18 + 8j, 12 - 10j, -14 - 60j, 20 + 20j]

def fourier(t, C):
    f = zeros(t.shape)
    for k in range(len(C)):
        f += C.real[k] * cos(k * t) + C.imag[k] * sin(k * t)
    return f

def elephant(t, p):
    npar = 6
    Cx = zeros((npar,), dtype='complex')
    Cy = zeros((npar,), dtype='complex')
    Cx[1] = p[0].real * 1j
    Cy[1] = p[3].imag + p[0].imag * 1j
    Cx[2] = p[1].real * 1j
    Cy[2] = p[1].imag * 1j
    Cx[3] = p[2].real
    Cy[3] = p[2].imag * 1j
    Cx[5] = p[3].real
    x = append(fourier(t, Cy), [p[4].imag])
    y = -append(fourier(t, Cx), [-p[4].imag])
    return x, y

def init_plot():
    # draw the body of the elephant
    # create trunk
    x, y = elephant(linspace(2.9 * pi, 0.4 + 3.3 * pi, 1000), parameters)
    for ii in range(len(y) - 1):
        y[ii] -= sin(((x[ii] - x[0]) * pi / len(y))) * sin(float(0)) * parameters[4].real
    trunk.set_data(x, y)
    return trunk,
```

..and move the trunk

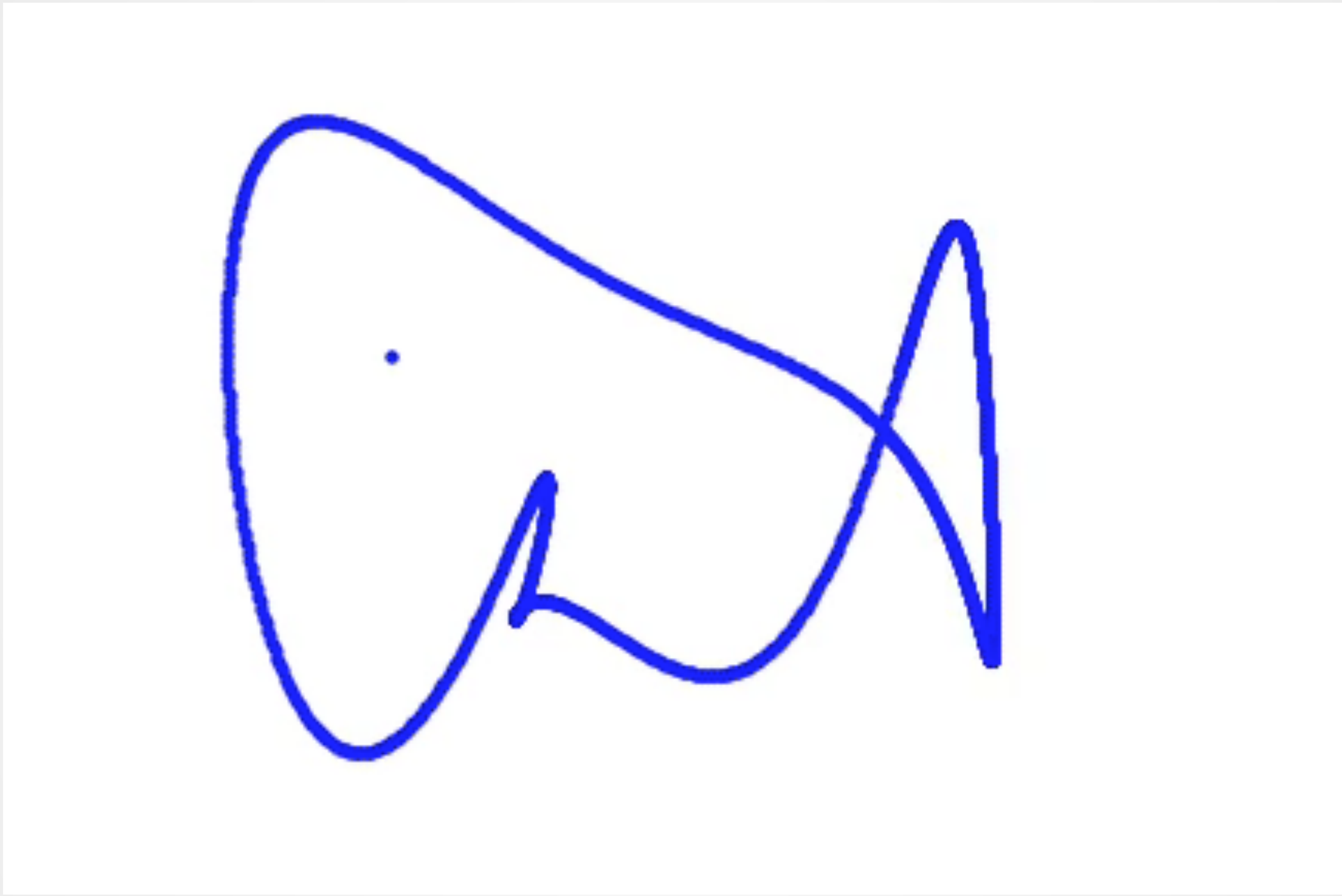
```
import matplotlib
matplotlib.use('TKAgg')
from matplotlib import animation
import matplotlib.pyplot as plt

def move_trunk(i):
    x, y = elephant(linspace(2.9 * pi, 0.4 + 3.3 * pi, 1000), parameters)
    for ii in range(len(y) - 1):
        y[ii] -= sin(((x[ii] - x[0]) * pi / len(y))) * sin(float(i)) * parameters[4].real
    trunk.set_data(x, y)
    return trunk,

fig, ax = plt.subplots()
# initial the elephant body
x, y = elephant(t=linspace(0.4 + 1.3 * pi, 2.9 * pi, 1000), p=parameters)
plt.plot(x, y, 'b.')
plt.xlim([-75, 90])
plt.ylim([-70, 87])
plt.axis('off')
trunk, = ax.plot([], [], 'b.')  # initialize trunk

ani = animation.FuncAnimation(fig=fig,
                              func=move_trunk,
                              frames=1000,
                              init_func=init_plot,
                              interval=500,
                              blit=False,
                              repeat=True)
plt.show()
```

Patrick’s happy spermwhale



$$f(t) = \sum_{k=0}^{5} \Big(A[k]cos\left(kt\right) + B[k]sin(kt) \Big)$$

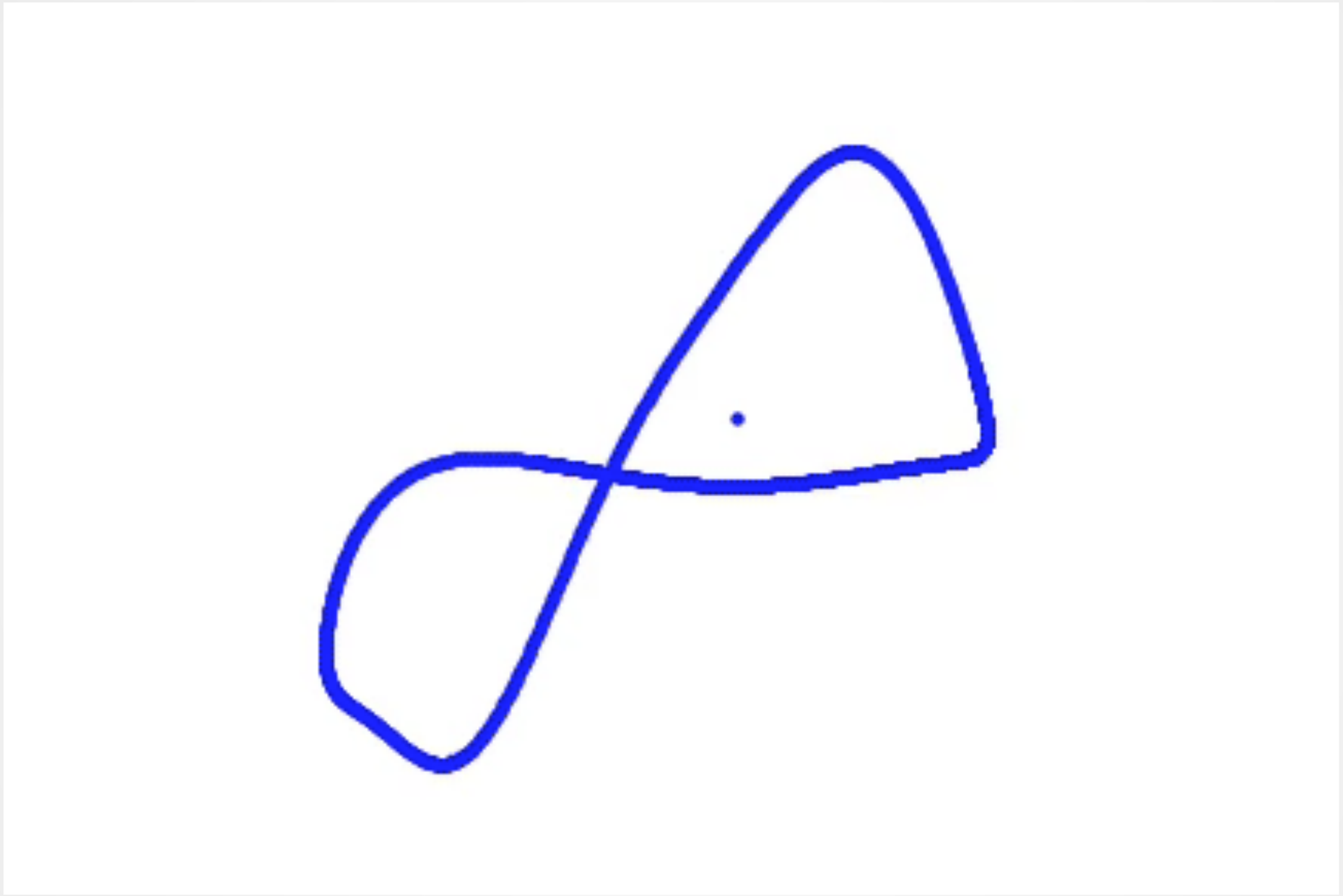
$$\Big(30sin(t) + 20sin(2t) + 40cos(3t) + 20cos(5t), -50cos(t) - 10sin(t) + 20sin(2t) + 10sin(3t)\Big)$$

Philipp’s flying swan

$$f(t) = \sum_{k=0}^{5} \Big(A[k] cos\left(kt\right) + B[k] sin(kt) \Big)$$

$$\Big(1sin(t) + 9sin(2t) + 1cos(3t) + 9cos(5t), + 9cos(t) - 2sin(t) + 9sin(2t) - 2sin(3t) \Big)$$

Kathrin’s hungry animal



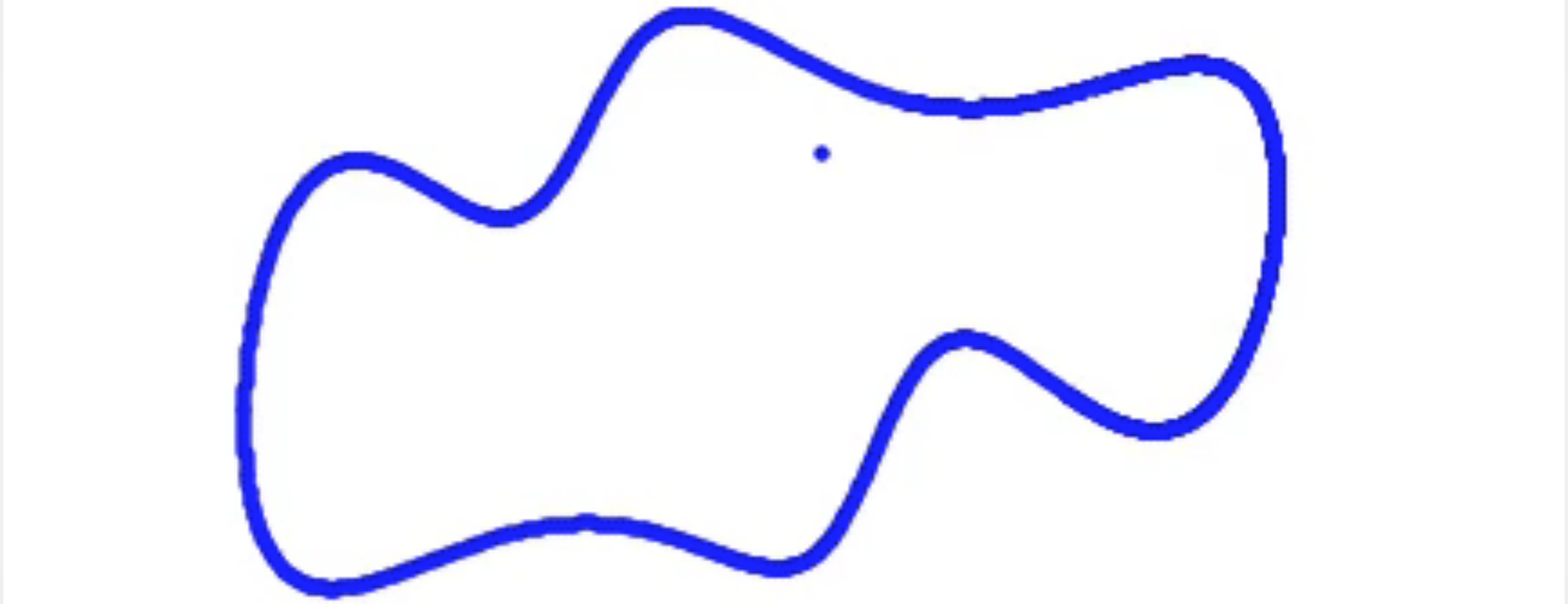
$$f(t) = \sum_{k=0}^{5} \left(A[k]cos\left(kt\right) + B[k]sin(kt) \right)$$

$$\left(50sin(t) + 30sin(2t) + 5cos(3t) - 5cos(5t), -6cos(t) - 50sin(t) + 10sin(2t) - 2sin(3t)\right)$$

Anna’s happy hippo

```
#parameters for the hippo:

parameters = [50 - 15j, 5 + 2j, -10 - 10j, -14 - 60j, -15 + 30j]
```



$$f(t) = \sum_{k=0}^{5} \Big(A[k]cos\left(kt\right) + B[k]sin(kt) \Big)$$

$$\Big(50sin(t) + 5sin(2t) - 10cos(3t) - 14cos(5t), -60cos(t) - 15sin(t) + 2sin(2t) - 10sin(3t)\Big)$$

DEDA Digital Economy & Decision Analytics

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