EFM Fall 2014, Week 3: More Python

Jason Phang, Allan Zhang

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1. IPython Notebooks
2. Assignment 1: Discussion
3. Basic Statistics
4. Functions
5. Libraries

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Starting IPython Notebooks

Another way of running Python code:

Run this in Terminal/Command Prompt

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- `notebook` is the subcommand, telling it to start the IPython notebook server

Starting IPython Notebooks

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Run this in Terminal/Command Prompt

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$ ipython notebook --pylab=inline
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- `ipython` is program you're running
- `notebook` is the subcommand, telling it to start the IPython notebook server
- `pylab=inline` is an option, telling IPython that you want to be able to plot in your notebooks

What are IPython Notebooks?

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- Each notebook contains a series of **cells**.

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- `.ipynb` files contain a combination of Python code, formatting information, text, and possibly images
- Used to present and document code, add in $\LaTeX$
- Extremely useful for exploratory data analysis
- Each notebook contains a series of **cells**.
- Cells can contain Code, Markdown (formatted text) or headings.

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- The server runs sessions of Python in the background, and feeds the output to your notebook
- Each notebook corresponds to one session - and you can close the notebook and re-open it to continue the same session

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Basic Operations

- `Ctrl-S` to save (or click the floppy disk)
- `Shift-Enter/Cmd-Enter` to run a cell
  - Equivalent to `%run`ing some code from a file
- **kernel** → **Interrupt**/**Restart** to kill/restart a Python process

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- Keep your code neat! Organize your cells, keep things in order!
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- Certain code does not work effectively in Notebooks

IPython Notebook Pro-tips

- Keep your code neat! Organize your cells, keep things in order!
- Cells always print the returned value of the last command, even if you don't ask it to
- Don't over-rely on notebooks
- Save frequently!
- Certain code does not work effectively in Notebooks
    - E.g. Certain kinds of plots

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- See: IPython Notebook

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- To learn more, take STAT 23400 or STAT 24400

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$$f(x) = \begin{cases} \frac{1}{2}, & \text{if } x = 1. \\ \frac{1}{2}, & \text{if } x = 0. \\ 0, & \text{otherwise.} \end{cases} \tag{1}$$

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    - E.g. Two Coin Flips (with outcome of flips being x_1,x_2):

$$f(x_1, x_2) = \begin{cases} \frac{1}{4}, & \text{if } x_1 = 1, x_2 = 1. \\ \frac{1}{4}, & \text{if } x_1 = 1, x_2 = 0. \\ \frac{1}{4}, & \text{if } x_1 = 0, x_2 = 1. \\ \frac{1}{4}, & \text{if } x_1 = 0, x_2 = 0. \\ 0, & \text{otherwise.} \end{cases} \tag{2}$$

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- E.g. An unfair coin:

$$f(x) = \begin{cases} \frac{1}{4}, & \text{if } x = 1. \\ \frac{3}{4}, & \text{if } x = 0. \\ 0, & \text{otherwise.} \end{cases} \tag{3}$$

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- E.g. Uniform distribution (for outcome between 0 and 10):

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  - Note that for continuous distributions, the value of the function does not really correspond to a "probability", but rather a "probability density"

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- Standard Normal distribution (all real numbers):

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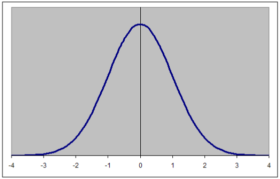

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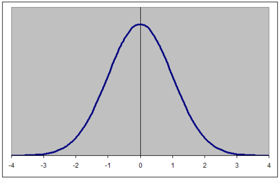

- Importantly, PMFs must sum to 1, and PDFs must integrate to 1, so that they can be considered ”probabilities”

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  - Standard deviation $= \sqrt{s^2}$
  - You might sometimes see a similar definition except using σ^2 and having the fraction $\frac{1}{N}$ instead. Don't worry about it - it has to do with the difference between an observed and theoretical data set, and usually the numerical differences are small.

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$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{(x-\mu)^2}{2\sigma^2}} \tag{8}$$

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  - The mean is μ and the variance is σ^2

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Functions

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Back to lovely, lovely coding!

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Functions

Back to lovely, lovely coding!

Functions

- A function is a pre-written set of instruction that you will run repeatedly
- In some ways similar to the mathematical definition of a function, in that it *often* takes in some input (known as **arguments**), and it *often* gives an output (known as **return**ing a value)
- Functions *will* be the most important thing you learn in programming

Functions

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- Start a definition using **def** and some parenthesis

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Simple function

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def greet_user():
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greet_user()
```

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Output

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Hello, friend!
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- Here's a function with an argument, and a return value

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Simple function

```
def square_this_number(x):
    return x*x

print square_this_number(10):
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Functions

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Simple function

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def square_this_number(x):
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Output

```
100
```

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Functions - Some Subtlety

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- Function gets called and prints ”Hello, friend!”

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Hello, friend!
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- Function gets called and prints ”Hello, friend!”
- Then Python tries to print the output value of the function, but there is none!

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Output

```
Hello, friend!
None
```

- Function gets called and prints ”Hello, friend!”
- Then Python tries to print the output value of the function, but there is none!
  - Yes, Python has an *object* called None, which is the default returned value

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Output

```
<function greet_user at 0x10bbabc08>
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- You're not calling the function, you're printing it!

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Simple function

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def greet_user():
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print greet_user
```

Output

```
<function greet_user at 0x10bbabc08>
```

- You're not calling the function, you're printing it!
- Python goes and prints the function as an object

Functions

Functions - Multiple Arguments

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Functions - Multiple Arguments

- You can supply multiple arguments

Simple function

```
def add_numbers(x,y):
    return x+y

print add_numbers(5,10)
```

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Functions - Multiple Arguments

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Simple function

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def add_numbers(x,y):
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print add_numbers(5,10)
```

Output

```
15
```

Functions

Function - A more complex example

Simple function

```
def find_maximum(ls):
    current_max = ls[0]
    for i in ls[1:]:
     if i > current_max:
         current_max = i
    return current_max

print find_maximum([5,3,1,2,3,1,4])
```

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Function - A more complex example

Simple function

```
def find_maximum(ls):
    current_max = ls[0]
    for i in ls[1:]:
     if i > current_max:
         current_max = i
    return current_max

print find_maximum([5,3,1,2,3,1,4])
```

Output

```
5
```

Functions

Function - They are not type-safe

Simple function

```
def find_maximum(ls):
    current_max = ls[0]
    for i in ls[1:]:
     if i > current_max:
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print find_maximum(3)
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print find_maximum(3)
```

Output

```
Some long error
```

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print find_maximum(3)
```

Output

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Some long error
```

- Functions don't check for the type of your input (unlike languages like C or Java), YOU (or your code) have to do that!

Functions

A function that literally does nothing

Simple function

```
def do_nothing():
    pass

do_nothing()
```

Functions

A function that literally does nothing

Simple function

```
def do_nothing():
    pass

do_nothing()
```

Output

Functions

A function as an object

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A function as an object

- You can also pass a function as an argument!

Simple function

```
def run_function_on_number(n,f):
    return f(n)

run_function_on_number(2.0,sqrt)
```

Functions

A function as an object

- You can also pass a function as an argument!

Simple function

```
def run_function_on_number(n,f):
    return f(n)


run_function_on_number(2.0,sqrt)
```

Output

```
1.4142135623730951
```

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Functions you already encountered

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- Python comes with some of its own built-in libraries. Canopy comes with TONS of libraries pre-installed.

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Libraries

- Libraries are prepackaged code written by other people!
- You can install libraries via `pip`, as we did on the first day
- Python comes with some of its own built-in libraries. Canopy comes with TONS of libraries pre-installed.
- To use code from a library, you have to **import** it.

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Importing Libraries

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import math
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Output

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2.71828182846
```

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Direct Import

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import math
print math.e
```

Import as

```
import math as my_mathematical_library
print my_mathematical_library.e
```

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- There are multiple ways to import a library
- Which method depends on how you want to name and refer to things

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print math.e
```

Import as

```
import math as my_mathematical_library
print my_mathematical_library.e
```

From .. Import

```
from math import e
print e
```

Libraries

Library - Random

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- The **random** library provides functions that generate random numbers

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import random

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random.randint(0,10)
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2
```

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Library - Math

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- Contains most common math functions

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```

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    - E.g. `math`, `numpy`, `pylab` etc
    - Sometimes your code written in IPython won't run elsewhere, because you need to explicitly import the libraries yourself

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Random

```
from matplotlib.pyplot import plot

plot(range(10))
plot(range(10),[1,-1,2,-2,3,-3,4,-4,5,-5])
```

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Random

```
from matplotlib.pyplot import plot, title, xlabel, ylabel

ls1 = range(10)
ls2 = [1,-1,2,-2,3,-3,4,-4,5,-5]

plot(ls,"xk")
plot(ls1,ls2,"--o")
xlabel("X-axis!")
xlabel("Y-axis!")
plt.title("Wow a title!")
```

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Random

```
from matplotlib.pyplot import plot, title, xlabel, ylabel, his
import random

normal_vals = [random.normalvariate(0,1) for i in range(10000)
hist(normal_vals)
```

Bye!

To-do!

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Next Week

Bye!

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Next Week

- Portfolio Theory!