

Getting Started with Python and Excel

Building a Basic Model in Both Excel and Python

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Approaching a Problem with Two Tools

- The focus today is to get familiar working in both Excel and Python
- We will approach this by building a simple model with both tools
- In later lectures, we will move to combining the tools

$$\begin{aligned}
 &u+vx+(-u+v)y+(5u+2v)z-3u+v=0 \quad (2) \\
 &x = x_1+mt, \quad y = y_1+nt, \quad z_1 = z+pt \\
 &x = mz+a, \quad y = nz+b \quad \frac{x-a}{m} = \frac{y-b}{n} = \frac{z}{1} \\
 &y^2 \quad (x+c)^2+y^2 = 4a-4a\sqrt{(x-c)^2+y^2+(x-c)^2} \\
 &\lim_{x \rightarrow 0} \left(\frac{1}{x} - \frac{1}{e^x-1} \right) = \lim_{x \rightarrow 0} \frac{e^x-1-x}{x(e^x-1)} = \frac{1}{2} \\
 &y' = (\ln u)' \quad (\sin x)' = \frac{1}{u} \cos x = \frac{\cos x}{\sin x} = \cot x \\
 &\int f(x) dx = \lim_{a \rightarrow 0} \int_a^b f(x) dx + \lim_{b \rightarrow 0} \int_{c+b}^b f(x) dx \quad \int f(x) dx \\
 &\lim_{x \rightarrow 0} \frac{4x}{\tan(\pi(2+x))} = \left\{ \frac{0}{0} \right\} = \lim_{x \rightarrow 0} \frac{4x}{2\pi x} = \frac{2}{\pi} \\
 &\sum_{i=1}^n x_i^2 + b \sum_{i=1}^n x_i = \sum_{i=1}^n x_i^2 y_i \quad a \sum_{i=1}^n x_i^2 + bn = \sum_{i=1}^n x_i^2 y_i \\
 &y = \pi - x, \quad x \rightarrow \pi, \quad y \rightarrow 0 \\
 &\sin 3x = \sin 3(p-y) = \sin(3p-3y) = \sin 3y
 \end{aligned}$$

A Simple Retirement Problem

- Let's take what is perhaps the simplest finance problem, which everyone should understand
- While you may have approached such a problem with a calculator before, we will build models for it instead
- Martha is saving for retirement. She earns \$60,000 per year and is able to save 25% of that. If she invests her savings, earning 5% per year, and she needs \$1,500,000 to retire, how soon can she retire?

Breaking Down the Retirement Problem

A General Structure

Inputs



Process



Outputs

Real-world Problem

Wages, Savings



Investment



Cash in the
bank, person
retires

A Model of the Problem

Cash Flows, Savings
Rate, Interest Rates



Model



FV of CF, time
until retirement

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Solving the Problem in Excel

- It is easy to use Excel as a calculator and just type the math in directly. But we want to build a model.
- Changing inputs should result in a change to outputs. The way to do this in Excel is cell references
- Fixed references become important when trying to drag formulas, e.g. $\$A\2 (fully fixed), $\$A2$ (fixed on column), or $A\$2$ (fixed on row).



Simple Retirement Problem in Excel

Intro Excel Exercise

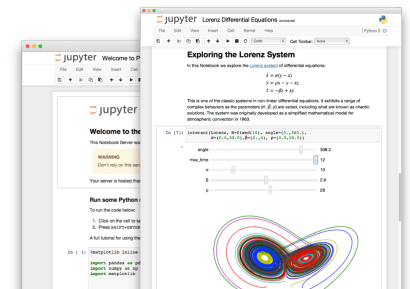
- Go to Canvas and download Simple Retirement Model.xlsx from Examples > Intro > Excel
- Follow along as I recreate the simple model.

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How We'll Work in Python

- Using Python in the terminal is kind of a pain. And so, tools were born.
- Jupyter is a graphical interface we can use for Python. It also supports over 40 other languages such as R, SAS, Julia, and Scala
- You can use jupyter notebook or jupyter lab. The latter has a lot more features outside of the notebook



Let's Get Set up with Jupyter

Launch Jupyter Notebook

- 1 Launch Anaconda Navigator
- 2 Find Jupyter Notebook on the main screen, and click launch
- 3 You should see a list of folders and files. Click New and then Python 3
- 4 Now you should see a code cell with `In []:` next to it

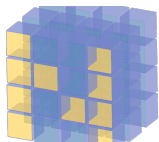
If you don't have Anaconda Navigator, just open a terminal (search `cmd` on Windows, `terminal` on Mac). Then in the terminal, type `jupyter notebook` and enter. Then continue with the third step.

Some Python Basics

- In Excel, the basic unit is a cell. In Python, the basic unit is an object.
- In Excel, content in a cell is either a number (123) or a string (ABC)
- In Python, all objects have types. They might also be a number or a string, or something else.
- Rather than using a cell reference like \$A\$2, we assign names to objects in Python

- ```
my_number = 6
my_string = 'ABC'
```

# Doing Some Math in Python



# NumPy

- Basic operations in Python are straightforward
- $2 + 5 = 7$
- $6 - 2 = 4$
- $2 * 3 = 6$
- $5 / 2 = 2.5$
- A lot more is available using the numpy package
- `np.pv`, `np.nper`,  
`np.fv`, `np.pmt`
- [All numpy financial functions](#)

# Simple Retirement Problem in Python

## Intro Python Exercise

- Go to Canvas and download Simple Retirement Model.ipynb from Examples > Intro > Python
- In Jupyter, then navigate to your Downloads folder (or wherever you saved it)
- You should then see Simple Retirement Model.ipynb come up in the list of files in Jupyter. Click it to open it and follow along.

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## Extending the Model - Multiple Interest Rates

- Now we've got basic models to determine how long it will take Martha to retire.
- We've got a few assumptions built into the model. One is that Martha will earn 5% on her investments
- Rates of return are volatile, so we want to see how long it would take her to retire if her return was different



# Programming Fundamentals - Iteration

- In programming, for model building or otherwise, you often need to repeat the same process for multiple different things
- In Excel, you would do this by dragging formulas.
- In Python, as in most other programming languages, we would use a for loop
- This says, do something, for each value I pass into the loop

# Iteration - Python vs. Excel

## Python Iteration

```
inputs = [5, 10, 15]
for item in inputs:
 new_value = item + 2
 print(new_value)
```

7

12

17

## Excel Iteration

| Input | Output | Function |
|-------|--------|----------|
| 5     | 7      | =B4+2    |
| 10    | 12     | =B5+2    |
| 15    | 17     | =B6+2    |

# Explaining Python Iteration

- There's a few things to unpack here
- Here's another type of object: not a number or a string, but a list
- A list holds multiple objects, and you can add or remove items from lists

## Python Iteration

```
inputs = [5, 10, 15]
for item in inputs:
 new_value = item + 2
 print(new_value)
```

```
7
12
17
```

# Explaining Python Iteration (pt. 2)

- Here we define a list of three numbers as inputs
- Then we use a for loop to get each input out of the list, and add 2 to it to create the new value
- Finally we print each value as it is generated

## Python Iteration

```
inputs = [5, 10, 15]
for item in inputs:
 new_value = item + 2
 print(new_value)
```

```
7
12
17
```

# Iterating the Existing Model

## Expanding on Python and Excel

- I will now expand the existing Excel and Python models to examine multiple interest rates
- Continue viewing the same previously downloaded files.

# Putting it All Together - A Basic Model with Iteration

## Let's Vary the Savings Rate, Too

- Now we want to see the effect of savings rate on time until retirement, in addition to interest rate
- In both Excel and Python, calculate the years to retirement for savings rates of 10%, 25%, and 40%, and each of these cases with each of the interest rate cases, 4%, 5%, and 6%
- Be sure that you drag formulas in Excel and use for loops in Python to accomplish this

## Note

In total you should have 9 calculated years to retirement numbers, in each of the two models.