Programming Principles in Python (CSCI 503/490)

Introduction

Dr. David Koop
Python Experience?
Programming Principles?
Why Python?
Productivity
Libraries, Libraries, Libraries
What about speed?
### Administrivia

- **Course Web Site**
- **TAs:** Naga Jyothi Kota & Angel Prathyusha Koyi
- **Syllabus**
  - Plagiarism
  - Accommodations
- **Assignments**
- **Tests:** 2 (Feb. 21, Apr. 3) and Final (May 6)
- **Course is offered to both undergraduates (CS 490) and graduates (CS 503)**
  - Grad students have extra topics, exam questions, assignment tasks
Academic Honesty

• Do not cheat!
• You will receive a zero for any assignment/exam/etc. where cheating has occurred
• You will fail the course if you cheat more than once
• Misconduct is reported through the university's system
• You may discuss problems and approaches with other students
• You may not copy or transcribe code from another source
Schedule

- Lectures are 12:30-1:45pm MW in PM 110
  - Better for learning if you are engaged
  - Ask questions
    - Please advise me of any issues
- Any changes will be announced as soon as possible
- Slides will be posted to the course website
Office Hours & Email

• TA office hours will be held in person in TA Offices
  - **Tentative:** M 2-5pm, Tu 9:30am-12:30pm, W 1:00-4:00pm, Th 9:30am-12:30pm

• Prof. Koop's office hours will be held in person in PM 461
  - M: 1:45-3:00pm, W: 10:45am-12:00pm, or by appointment
  - You do not need an appointment to stop by during scheduled office hours,
  - If you wish to meet virtually, please schedule an appointment
  - If you need an appointment, please email me with details about what you wish to discuss and times that would work for you

• Many questions can be answered via email. **Please consider writing an email before scheduling a meeting.**
Course Material

• Textbook:
  - Recommended: Python for Programmers
  - Good overview + data science examples
• Many other resources are available:
  - http://www.pythontutor.com
  - https://www.python-course.eu
  - https://software-carpentry.org/lessons/
Course Material

• Software:
  - Jupyter Notebook: Web-based interface for interactively writing & executing Python code
  - JupyterLab: An updated web-based interface that includes the notebook and other cool features
  - JupyterHub: Access everything through a server
Python

• Started in December 1989 by Guido van Rossum
• “Python has surpassed Java as the top language used to introduce U.S. students to programming…” (ComputerWorld, 2014)
• Python is also a top language for data science
• High-level, interpreted language
• Supports multiple paradigms (OOP, procedural, functional)
• Help programmers write readable code, use less code to do more
• Lots of libraries for python
• Designed to be extensible, easy to wrap code from other languages like C/C++
• Open-source with a large, passionate community
Python the #2 Programming Language in 2022
Even Wider Gap in Google Tutorial Searches

[Log-Scale Graph showing the popularity of programming languages from 2005 to 2022. The languages include C/C++, Java, JavaScript, Python, and R. The graph is on a log-scale.]
Stack Overflow Language Usage

- **JavaScript**: 65.36%
- **HTML/CSS**: 55.08%
- **SQL**: 49.43%
- **Python**: 48.07%
- **TypeScript**: 34.83%
- **Java**: 33.27%
- **Bash/Shell**: 29.07%
- **C#**: 27.98%
- **C++**: 22.55%
- **PHP**: 20.87%
- **C**: 19.27%
- **PowerShell**: 12.07%
- **Go**: 11.15%
- **Rust**: 9.32%

[Stack Overflow Developer Survey, 2022]
AWS remains not only the most used cloud platform but also the most wanted by developers saying they want to continue using it. Rust is on its seventh year as the most loved language with 87% of technologies/tools that are maintaining their position as most loved.

Most loved, dreaded, and wanted

Windows is the most popular operating system for developers, across professional and learning to code.

Synchronous tools

Jira is most widely used collaborative work management tool by developers.

Other tools

PyCharm is used more by people learning to code (26% vs 16%) while Visual Studio and Git are used more by professional developers. Machine learning frameworks like TensorFlow and Scikit-learn are well-liked by developers.

Stack Overflow Developer Survey, 2022
StackOverflow Language Interest

Loved vs. Dreaded

Want

Rust: 17.6%
Python: 17.59%
TypeScript: 17.03%
Go: 16.41%
JavaScript: 12.98%
Kotlin: 8.08%
C++: 7.67%
SQL: 6.51%
C#: 6.11%
Java: 5.6%
Dart: 4.83%
C: 4.34%
Swift: 4.3%

71,467 responses
% of developers who are not developing with the language or technology but have expressed interest in developing with it.

[Stack Overflow Developer Survey, 2022]
Modes of Computation

• Python is **interpreted**: you can run one line at a line without compiling

• Interpreter in the Shell
  - Execute line by line
  - Hard to structure loops
  - Usually execute whole files (called scripts) and edit those files

• Notebook
  - Richer results (e.g. images, tables)
  - Can more easily edit past code
  - Re-execute any cell, whenever
Python Differences

• Dynamic Typing
  - A variable does not have a fixed type
  - Example: `a = 1; a = "abc"

• Indentation
  - Braces define blocks in Java, good style is to indent but not required
  - Indentation is critical in Python
    ```python
    z = 20
    if x > 0:
      if y > 0:
        z = 100
    else:
      z = 10
    ```
JupyterLab and Jupyter Notebooks

In this Notebook we explore the Lorenz system of differential equations:

\[
\begin{align*}
\dot{x} &= \sigma(y - x) \\
\dot{y} &= x\rho - y - xz \\
\dot{z} &= xy - \beta z
\end{align*}
\]

Let's call the function once to view the solutions. For this set of parameters, we see the trajectories swirling around two points, called attractors.

```python
In [4]: from Lorenz import solve_Lorenz

t, x_t = solve_Lorenz(N=50)
```
Jupyter Notebooks

• Display rich representations and text
• Uses Web technology
• Cell-based
• Built-in editor
• GitHub displays notebooks
Jupyter Notebooks

• An interactive programming environment
• Runs in your web browser
• Displays results (even interactive maps) inline
• Originally designed for Python
• Supports other languages, too
• You decide how to divide code into executable cells
• Shift+Enter (or the "play" button) to execute a cell
Notebooks in JupyterLab

• Directory view on left
• Create new notebooks using "+" button, "New" from the File menu, or Launcher window
  - Notebook originally has name "Untitled"
  - Click on "Untitled" to change the name (do this!)
• Save a notebook using the command under the File menu
• Shutting down the notebook — use Close and Shutdown Kernel
  - Web browser is interface to display code and results
  - Kernel actually runs the code: usually see messages in a console/terminal window
Notebooks in JupyterLab

• Open a notebook by going back to the file browser and clicking on it like you would in a desktop view
• Past results are displayed—does not mean they are loaded in memory
• Use "Run All" or "Run All Above" to re-execute past work
  - If you shut down the kernel, all of the data and variables you defined need to be redefined (so you need to re-run all)
  - **Watch Out — Order Matters:** If you went back and re-executed cells in a different order than they are shown, doing "Run All" may not produce the same results!
• Edit mode (green) versus Command mode (blue == **Be Careful**)
• Learn keyboard shortcuts
Notebooks in JupyterLab

• Can write code or plain text (can be styled Markdown)
  - Choose the type of cell using the dropdown menu
• Cells break up your code, but all data is global
  - Defining a variable \(a\) in one cell means that variable is accessible in any other cell
  - This includes cells above the cell \(a\) was defined in!
• Remember Shift+Enter to execute
• Enter just adds a new line
• Use ?<function_name> for help
• Use Tab for auto-complete or suggestions
JupyterLab

• More than just notebooks:
  - Text editor
  - Console
  - Custom components (Many extensions)

• Arrange multiple documents and views

• JupyterLab Documentation
Using Python & JupyterLab Locally

• www.anaconda.com/download/
• Anaconda has JupyterLab
• Use Python 3.12
• Anaconda Navigator
  - GUI application for managing Python environment
  - Can install packages
  - Can start JupyterLab
• Can also use the shell to do this:
  - $ jupyter lab
  - $ conda install <pkg_name>
Using Python & JupyterLab on Course Server

• Stay tuned…
Chicago Food Inspections

• Data: Information about food facility inspections in Chicago
• Data Source: https://data.cityofchicago.org/Health-Human-Services/Food-Inspections/4ijn-s7e5/data
• Fields: Name, Facility Type, Risk, Violations, Location, etc.
Chicago Food Inspections Exploration

- Based on David Beazley's PyData Chicago talk
- YouTube video: https://www.youtube.com/watch?v=j6VSAsKAj98
- Our in-class exploration:
  - Don't focus on the syntax
  - Focus on how interactive Python makes this exploration work well