Physics 91SI: Practical Computing for Scientists

Spring Quarter, 2015–2016

The Teaching Team:

Faculty Sponsor:
Risa Wechsler, Associate Professor of Physics and of Particle Physics and Astrophysics

Instructors:
Andrew Guo, aguoman@stanford.edu
Office Hours: By appointment

Kaitlyn Shin, kshin2@stanford.edu
Office Hours: Tu 6:30-7:30pm

Learning and coding can both be frustrating. Feel free to come by our office hours so that we can help you resolve the issues that are frustrating to you. We are also happy to use office hours to go beyond the scope of the course, or just to chat about coding in Python and why we care about it.

Course Goals/Requirements:

This course teaches essential computer skills for researchers in the natural sciences. The goal is to provide students with the essential and most powerful tools used in modern research environments. The course will be taught primarily using the UNIX operating system and the Python programming language, but with an eye toward the different computing environments used in research situations.

By the end of this course, you should be a self-sufficient programmer and software user. This means that you will be able to:

1. Navigate the UNIX operating system and use many of its powerful utilities, including shell scripting, version control, and distributed file systems.
2. Be confident using the Python programming language, including advanced data structures, object-oriented programming, functional programming, and debugging tools.
3. Use scientific analysis and plotting libraries, and integrate Python with the preferred operating system and data workflow.
4. Plot and present data in an effective and informative manner
5. Autonomously find, incorporate and learn to use the best external libraries for the task at hand
6. Write fast, efficient and optimized code for time-critical applications using the C programming language and the Cython extension to python

While examples will be drawn primarily from physics, these skills are highly useful in any scientific discipline involving quantitative analysis and are generally considered very desirable qualifications for research positions.

Prerequisite:

CS 106A or equivalent. We'll teach Python as a second language, not a first language.

Lecture/Lab policy:

- Course meets Tuesday, Thursday 4:30-6:20 in Lathrop 294.
- 2 combination lecture/lab sessions per week, with mandatory attendance.

Assignments and Grading:

This class is graded on a Satisfactory/No Pass basis. In order to guarantee a passing grade, you need to

- Complete the final project satisfactorily on time, in its entirety (see long syllabus).
- Attend every session, including lesson and lab (nineteen in total).
- Submit substantial working code at the end of every lab (via Github).

In particular, we will allow up to one excused absence. Any following absences must be approved in advance by the faculty sponsor, Professor Risa Wechsler (rwechsler@stanford.edu).

Our job is to make every class of the class transparent, rewarding and productive for you. Our plan for the class includes scaffolds to help you learn smoothly from assignments. Daily lab assignments and weekly final project milestones will be handed out in paper and/or online, and our expectations will be articulated verbally.

Course Website: http://physics91si.stanford.edu

Throughout the course, we will maintain a website for your reference. This website will have final project reminders, PDFs of handouts from class, and additional resources for your perusal.

Announcements will be emailed and posted on the course website.

Students with Documented Disabilities

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066, URL: http://studentaffairs.stanford.edu/oae).

Small Syllabus:

Week 1, Introduction to Unix and Python:

a. Unix, File System, Text Editors
b. Language Basics
    i) python interpreter
    ii) python scripts
    iii) control (if, while/for loops)
    iv) functions

Week 2, Python Introduction (continued), GIT:

a. Advanced Unix, mercurial (GIT), shell scripts, piping
b. Data structures
    i) lists, tuples
    ii) dictionaries
    iii) sets, stacks, queues
    iv) arrays
c. Print debugging
    i) Jupyter/iPython notebook

Week 3, Numerical and Scientific Python:

a. Numpy, numpy arrays,
b. Scipy, matplotlib
c. How to read errors

Week 4, Advanced Python:

a. Functional Python
    i) list comprehensions, mappings
    ii) lambda functionals
    iii) passing functions as arguments
b. More matplotlib, scipy
c. How to write docs

Week 5, Object-Oriented Programming:

a. Classes, Modules, Exceptions
    i) scope, namespaces, reloading, dir
    ii) operator overloading and special functions

iii) python data hierarchy: code as data!

b. Exception-catching and debugging

i) unit tests

c. How to write docs

Week 6, Python Capstone Project:

a. How to find, incorporate and learn new libraries

b. Autonomous project work time

Week 7, Advanced Topics

a. Advanced plotting

b. Regexes

c. Project work time

Week 8, Advanced Topics and/or Other languages:

a. Integrated packages, e.g. Mathematica, Julia

b. Guest lecture/project work time

Week 9, Speed:

a. Intro to optimization

i) Runtime analysis

ii) Loops

iv) Vectorization

b. The C programming language (and why it's fast), Cython.

Week 10, Project Presentations

- Moving on from here

i) Trends in scientific computing

ii) Other important topics to learn about

iii) Courses at Stanford