Introduction to Scientific Programming

ASTR 2600 – Summer 2022

M/W/F 01:00PM – 02:25PM – SBO S125

Website: [**https://canvas.colorado.edu/**](https://canvas.colorado.edu/)

**Instructor**: Dr. Hadi Madanian ([hadi.madanian@colorado.edu](mailto:hadi.madanian@colorado.edu)) *(he, him)*

Phone: (303) 735-1717

Office Hours: SBO Computer Lab: Wed 02:30 – 3:00PM or by appt.

# Requirements for COVID-19

As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. CU Boulder currently requires COVID-19 vaccination and boosters for all faculty, staff, and students. Students, faculty, and staff must upload proof of vaccination and boosters or file for an exemption based on medical, ethical, or moral grounds through the [MyCUHealth portal](https://mycuhealth.colorado.edu/).

The CU Boulder campus is currently mask-optional. However, if public health conditions change and masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to [Student Conduct and Conflict Resolution](https://www.colorado.edu/sccr/). For more information, see the policy on [classroom behavior](http://www.colorado.edu/policies/student-classroom-and-course-related-behavior) and the [Student Code of Conduct](http://www.colorado.edu/osccr/). If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the [Public Health Office](https://www.colorado.edu/health/public-health/quarantine-and-isolation) ([contacttracing@colorado.edu](mailto:contacttracing@colorado.edu)). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the [Public Health Office](https://www.colorado.edu/health/public-health/quarantine-and-isolation) ([contacttracing@colorado.edu](mailto:contacttracing@colorado.edu)).

**Who Should Take This Course:** The techniques you will learn in this course will enable you to do complex scientific calculations with a powerful programming language. This is a basic requirement for astrophysics research, and for science in general, engineering, and information technology. You will have to think logically and linearly, and after this class you will be able teach yourself more extensive computer programming in Python and other programming languages. Thus, this course is for students who want to learn a valuable skill and a way of thinking that will prepare them for astrophysics research or other technical fields.

**Prerequisites:** Because of the physical/mathematical examples used in the course, this course has prerequisites of Physic I and Calculus I. Additionally, this course will be easier for you if you have experience with high school algebra, geometry, and have an understanding of scientific notation.

**Course Goals:** My goals for this class are for you to…

* Learn the principles of (scientific) programming
* Write computer programs with the Python language
* Master an essential tool for astronomical research
* Gain confidence creating complex programs
* Learn how to learn more with Python and other languages

**Course Content:**

* The Python programming language
* Principles and practices of scientific programming
* Data visualization and analysis
* Astronomical examples

**Course Format:** Each class will consist of (roughly):

* A 45-minute interactive lecture
* A 40-minute tutorial session in which you will execute code we have written, answer questions about it, and write some code of your own

**Grading:**

20% Daily tutorials. Due by midnight on the day *after* they are done in class. (Lowest two dropped.)

40% Weekly homework. Due 5pm on the due date. (Lowest one dropped.)

15% Midsemester Exam (July 1, conducted during class time.)

25% Semester project (an N-body code). Due at the *start* of the last class of the semester (Aug 5).

**Helpful Texts:**

“Introduction to Computation and Programming Using Python,” 2nd edition, by John V. Guttag. This is an excellent text: it has all the basics, it is very clear, and you will use it as a reference in the future. It is available online for free through the CU library.

“Python for Kids,” by Jason R. Briggs. Contains great explanations and great references. Good for all ages! CU Library: <http://tinyurl.com/y6jocngl>

“A Whirlwind Tour of Python," by Jake VanderPlas. An astronomer turned software engineer! Science-minded, interactive tutorials. <https://github.com/jakevdp/WhirlwindTourOfPython>

**Canvas:** You will use Canvas to turn in homework and tutorials, to access grades, and to receive announcements. You can log on with your IdentiKey. It is your responsibility to check Canvas frequently for announcements and to keep track of your grades – do not wait to the end of the semester to discover that there is something wrong with your scores!

**Software:** We will use Python 3.x for this class (anything above Python 3.6 is acceptable). Everything you need is pre-installed on the computers in the computer lab, and I encourage you to use those servers for your work. You are free to access these servers via terminals in the SBO computer room or your own computer (including bringing your own laptop when you attend class in-person). Instructions will be provided in class and on Canvas. Alternatively, if you would like to install Python on your own computer, you are welcome to do so. See the Choose-Your-Own-Adventure content section on Canvas for guidance on this.

**Attendance & Homework:** Attendance is *strongly* encouraged. Late homework or tutorials submitted without contacting me first will not be graded. I recognize though that things do come up. In the case of illness, emergency, campus schedule conflicts, observances of religious holidays, or *any* other reason why you may not be able to meet an assignment due date, please contact me right away *— before the due date! —* to make special arrangements.

**Common Courtesy:** For the benefit of your fellow students and your instructor, you are expected to practice common courtesy with regard to all course interactions. For example:

1. Act as mature and responsible adults at all times.
2. Show up to class on time, and be prepared to learn when class starts.
3. Do not leave class early and **do not start packing up before class is over**.
4. If you must arrive late or leave early, please do not be disruptive.
5. **Please do not use cell phones in class** (this includes text messaging).
6. **Please do not constantly surf the web or social media** on your laptop. It distracts you and others.

If you follow these requests, I will practice common courtesy towards you: ending class on time and dealing with you as individuals and as adults.

***Approximate Topics & Assignment Schedule***

*(Due dates may change as the semester progresses and are given only for rough purposes.)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lecture | Date | Topics | Tutorial | Homework Due (next day) |
| 0 | 1-Jun | Introduction |  |  |
| 1 | 3-Jun | jupyter, Print, Data Types, Math | 1 |  |
| 2 | 6-Jun | Import, While Loops, Booleans | 2 |  |
| 3 | 8-Jun | For Loops & Lists | 3 | A |
| 4 | 10-Jun | Nested Loops & Lists | 4 |  |
| 5 | 13-Jun | Functions & Tuples | 5 | B |
| 6 | 15-Jun | Numpy/Arrays | 6 |  |
| 7 | 17-Jun | If & Plotting | 7 |  |
| 8 | 20-Jun | Dictionaries | 8 | C |
| 9 | 22-Jun | Reading Files | 9 |  |
| 10 | 24-Jun | Advanced Functions | 10 | D |
| 11 | 27-Jun | Arrays & Plotting (Playing with Data) | 11 |  |
| 12 | 29-Jun | Numerical Differentiation | 12 | E\* |
|  | 1-Jul | MIDTERM EXAM | - | - |
|  | 4-Jul | Independence Day (no class) |  |  |
| 13 | 6-Jul | Modules & Packages | 13 |  |
| 14 | 8-Jul | Numerical Integration | 14 | F |
| 15 | 11-Jul | Debugging, Error Handling | 15 |  |
| 16 | 13-Jul | Multidimensional Arrays | 16 | G |
| 17 | 15-Jul | Astronomical Imaging | 17 |  |
| 18 | 18-Jul | Random Numbers | 18 |  |
| 19 | 20-Jul | Monte Carlo Simulations | 19 | H |
| 20 | 22-Jul | Intro to Classes | 20 |  |
| 21 | 25-Jul | Writing Classes | 21 | I |
| 22 | 27-Jul | Animations | 22 |  |
| 23 | 29-Jul | Data Visualization | - |  |
| 24 | 1-Aug | Astropy | 23 | Project Draft |
| 25 | 3-Aug | Final Project Work Day | - |  |
| 26 | 5-Aug | Odds & Ends | Final Project^ |  |

\*Due on Tuesday after July 4th

\*\*Optional (not for credit)

^Due at the start of our class

**CU Honor Code:** All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code ([honor@colorado.edu](mailto:honor@colorado.edu)); 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the [Honor Code Office website](https://www.colorado.edu/osccr/honor-code).

**Classroom Behavior:** Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy.  For more information, see the policies on [classroom behavior](http://www.colorado.edu/policies/student-classroom-and-course-related-behavior) and the [Student Code of Conduct](https://www.colorado.edu/sccr/sites/default/files/attached-files/2020-2021_student_code_of_conduct_0.pdf).

**Preferred Names & Pronouns:** CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

**Students with Disabilities:** If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed.  Disability Services determines accommodations based on documented disabilities in the academic environment.  Information on requesting accommodations is located on the [Disability Services website](https://www.colorado.edu/disabilityservices/). Contact Disability Services at 303-492-8671 or [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu) for further assistance.  If you have a temporary medical condition, see [Temporary Medical Conditions](http://www.colorado.edu/disabilityservices/students/temporary-medical-conditions) on the Disability Services website.

**Religious Observances:** Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please contact Dr. Madanian in advance of the religious observation to make possible arrangements. See the [campus policy regarding religious observances](http://www.colorado.edu/policies/observance-religious-holidays-and-absences-classes-andor-exams) for full details.

**Extracurricular Activities:** Students formally affiliated with curricular and extracurricular University-related activities are required to communicate in writing with the instructor about potential conflicts within the first week of class or as soon as the student learns of a conflicting event. This deadline is established in order to provide students with time to change their course schedule if necessary. Instructors are not obligated to accommodate any potential conflicts, but may, at their own discretion, allow reasonable accommodations for these absences.

**Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation:** The University of Colorado Boulder (CU Boulder) is committed to fostering an inclusive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or [cureport@colorado.edu](mailto:cureport@colorado.edu). Information about the OIEC, university policies, [anonymous reporting](https://cuboulder.qualtrics.com/jfe/form/SV_0PnqVK4kkIJIZnf), and the campus resources can be found on the [OIEC website](http://www.colorado.edu/institutionalequity/).

Please know that faculty and graduate instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

**Questions & Problems:** Please don’t hesitate to get in touch with myself or TA if you have questions about any aspect of the class, or if you start running into difficulties following the material or keeping up with assignments – remember, **we’re here to help!**