

# ASTR 513

## Computational and Statistical Methods for Astrophysics (Fall 2023)

**Lectures:** 10:15 AM - 11:30 AM AZ time Monday, Wednesday

**Location:** Steward 208 or zoom <https://arizona.zoom.us/j/6849448207>

**Instructor:** Dr. Tim Eifler

**Email:** [timeifler@arizona.edu](mailto:timeifler@arizona.edu)

**Office hours:** Tue 3:00 - 4:00pm, Steward 322 or 208, please email to set an appointment

**Course description:** ASTR 513 is a grad level course introducing basic statistical concepts and computational methods that are used in current research problems in astrophysics. Numerical topics will include solution of non-linear systems of equations, ordinary and partial differential equations, Fourier techniques, Monte Carlo simulations, and basic information theory. Statistical topics will include frequentist and Bayesian inference methods, non-linear regressions methods, modeling of data, Monte Carlo techniques, error estimation, model selection, and basic applications of Machine Learning.

**Grading:** Course grade will be based on homework and the term project paper and presentation.

**Homework Assignments:** There will be approximately 6 homework assignments, one every 2 weeks. All information will be available on d2l and homework submission will also be via d2l.

**Term Project:** The term project is composed of a project paper (5 pages, please submit by **Dec 6** via email or upload to github) and a 25+10 min presentation that takes place during the last weeks of the semester. The topic is “Computational and Statistical Methods for Astrophysics” and the specific topic is at the discretion of the student. The general concept is to read and understand of the paper and to explain the computational/statistical techniques used in the paper as well as the scientific application. Implementation of the code used in the paper (e.g. in a simplified toy-model if otherwise too computationally demanding) and reproducing the results are the ultimate goal. The work needs to have a code component that can be run in google colab and the code needs to be made available through github. Please start thinking about your project early and discuss the concept with the instructor multiple times. You have to prepare a 1-page concept paper on your proposed work that needs to be signed off by the instructor before you can start the project. The first version of the concept paper is due Oct 1, the final version on Oct 15; it is highly recommended to discuss your idea the instructor before.

**Texts:** We will use several sources. Text and material will be provided. Some recommended reading is 1) *Bayesian Data Analysis*, Gelman, Carlin, Stern, Rubin 2021, <http://www.stat.columbia.edu/~gelman/book/BDA3.pdf>, 2) *Information Theory, Inference, and Learning Algorithms*, MacKay 2005 <https://www.inference.org.uk/>

[itila/book.html](#), 3) *Statistics, Data Mining, and Machine Learning in Astronomy* (Ivezic, Connolly, Vanderplas, Gray, 2019), 4) *Modern Statistical Methods for Astronomy* (Feigelson & Babu 2012), and for later applications in data visualization and ML we will use the online resource <https://scikit-learn.org/stable/>. Additional texts/software will be provided via d2l.

**Course Objectives and Expected Learning Outcomes:** The overarching goal of this course is for you to understand 1) basic computational and statistical methods including basic concepts of ML, 2) their usefulness and limits in the context of astrophysical science questions, and 3) to develop the skills to use these concepts in the context of your own research. This course is designed to help you develop your coding skills, critical reasoning ability, and evidence-based problem solving skills.

**Incomplete/Withdrawal:** Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at <http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete> and <http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively.

**Course Website:** In this class we will make use of D2L. It is your responsibility to check D2L regularly for course announcements/updates and assignments.

**Classroom Behavior Policy:** To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

**Threatening Behavior Policy:** The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

**Code of Academic Integrity:** Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: <http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

**UA Nondiscrimination and Anti-harassment Policy:** The University is committed to creating and maintaining an environment free of discrimination; see <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>.

**Academic advising:** If you have questions about your academic progress this semester, or your chosen degree program, please note that advisors at the Advising Resource Center can guide you toward university resources to help you succeed.

**Life challenges:** If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at 520-621-2057 or

DOS-deanofstudents@email.arizona.edu.

### **Make Time for Your Mental Health & Wellbeing - Some Resources**

The semester ahead may come with ups and downs, but there are lots of ways to support yourself, like self-care, talking with friends and family, or getting a fresh perspective from a supportive group. Stress is a normal part of life and may even motivate you sometimes, but chronic or overwhelming stress can affect your mental health and wellbeing. Pay attention to your personal signs that you're overly stressed, like changes in your mood, appetite, sleep, behavior, or new physical symptoms (aches, pains, etc.) that interfere with school and daily life. If you notice these signs or have questions about helpful resources, I welcome you to talk with me. You can also visit [caps.arizona.edu/mental-health](https://caps.arizona.edu/mental-health) for mental health tools and resources.

**Health & Wellness:** Campus Health provides quality medical, mental health, and wellness services for students. Visit <https://health.arizona.edu> or call 520-621-9202 (520-570-7898 for help after hours)

**Mental Health:** Campus Health's Counseling & Psych Services offers a range of mental health support tools and services like self-care strategies, peer support, groups and workshops, and professional mental health services. Visit <https://caps.arizona.edu/mental-health> or call CAPS 24/7 at 520-621-3334 to learn more.

#### **Crisis Support:**

Suicide & Crisis Lifeline: call 988

Crisis Text Line: text TALK to 741-741

Visit <https://preventsuicide.arizona.edu> for more suicide prevention tips and resources

**Accessibility and Accommodations:** At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, <https://drc.arizona.edu/>) to establish reasonable accommodations.

**Equipment and software requirements:** For this class you might need access to the following hardware: laptop or web-enabled device with webcam, headphone, and microphone; regular access to reliable internet signal; ability to download and run software. Google CoLab, Jupyter lab, or jupyter notebook with some version of python 3 (please go for 3.7 if you are installing from scratch) are required for the term project and the exercises. The term project should be written in latex (overleaf). github username and access are also required.

**Class Recordings:** This class is not recorded. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension or civil action. You may record the class for your private notetaking purpose, but widely sharing/publication is disallowed.

**Safety on Campus and in the Classroom** For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): <https://cirt.arizona.edu/case-emergency/overview>  
Also watch the video available at [https://arizona.sabacloud.com/Saba/Web\\_spf/NA7P1PRD161/](https://arizona.sabacloud.com/Saba/Web_spf/NA7P1PRD161/)

<common/learningeventdetail/crtfy000000000003560>

**Subject to Change Statement:** Information contained in the course syllabus may be subject to change as deemed appropriate by the instructor. Updates will be announced.