Astronomy 51/151: Astrophysics Laboratory

This class is aimed at people majoring in the physical sciences, especially those who are majoring in astrophysics. Through lectures and projects, the student will 1) learn practical statistical tools and error analysis, 2) develop and/or strengthen computer coding skills, 3) develop and strengthen a critical thinking attitude, 4) perform actual measurements on real astronomy datasets to derive properties of stars, galaxies, dark matter, dark energy and the expansion of the universe, etc., and 5) strengthen ability to work as part of a group and collaborative work.

This is NOT an introductory course in Astronomy. The Astrophysics lab is a course through which you will be introduced to research in astrophysics. Because astrophysics research is massively performed through coding, you will be doing lots of this. Therefore, the Astrophysics lab course is a fantastic opportunity to either develop your coding skills, or to strengthen them.

The course will start with a few lectures on practical numerical methods, statistics, error analysis, and data fitting methods which will be used during the whole course to successfully perform the assigned projects/experiments. During these first month, the students will start becoming familiar with coding. The preferred choice for the coding language is Python, as it has an extremely rich astronomy library and it is free. Alternatives to Python will be considered on an individual basis. The students will be divided into groups of 3-4 people, and each group will work independently on the assign project. The projects will consists of a combination of data reduction, measurements, analysis of the measurements, and interpretation. The students will start work on the projects in class, under the guidance of the instructor, but they are expected to invest significant number of hours outside of classroom to successfully complete the project.

ATTENDANCE IS MANDATORY.

SEEK HELP WHEN YOU NEED IT! I expect to see each of you in my office hours several times during this semester.

Lectures:

Fridays from 9:00 AM to 11:30 AM, Room 202 at 574 Boston Avenue.

ZOOM will be used for the first lecture and for office hours when needed. Zoom meeting information:

https://tufts.zoom.us/j/91348724404

Meeting ID: 913 4872 4404

A PASSWORD IS REQUIRED TO JOIN. THIS WILL BE SENT SEPARATELY

Instructor:

Prof. Danilo Marchesini, CLIC, Room 312-E

Office Telephone: (617) 627-2756

Email Address: Danilo.Marchesini@tufts.edu

Office Hours:

Whenever you need to meet with me, just send me an email, and we will schedule the most convenient day/time. I can meet students individually or as a group, whatever works best. In-person meetings are to be preferred, but remote meetings on zoom can also be arranged. Do not hesitate to contact me as soon as you encounter difficulties in the course, especially for homework sets (but in general, for any matter).

Prerequisites:

Physics 11 and 12 (co-prerequisite), or instructor's consent. Calculus will be used.

Knowledge of a coding language highly preferable: Python would be the best.

Requirements:

ATTENDANCE IS MANDATORY. If, for whatever reasons, you are not able to attend a lecture, please notify the instructor as soon as possible as well as your project partners. To attend this course, you are required to sign a document stating that you are familiar with the Rules of Academic Integrity and promise to exercise the highest standards of academic honesty in this course. This document is at the end of the syllabus.

Textbook

I require the use of the book "Practical Statistics for Astronomers", 2nd Edition, by J.V. Wall and C.R. Jenkins. This book is available at the Tufts Bookstore, but you are more than welcome to find the cheapest available version.

Course Website

http://cosmos.phy.tufts.edu/~danilo/AST51/AST51.html. You should check this site regularly, especially for the updated syllabus and schedule of the course, and other documents.

SLACK Channel

To facilitate and encourage collaborative work, I created a Slack channel. Join in using the following link:

https://join.slack.com/t/ast-51151/shared_invite/zt-121i73tzo-sV46op5ccytsjIx6iLKqrA

Course Format

During the first month, we will focus on learning a few practical numerical methods, concepts in statistics and error analysis, and methods of data fitting, which will be used throughout the rest of the course to performed the assigned projects. We will also learn a few basic astronomy concepts (e.g., magnitudes, redshift, etc). After that, we will engage in a series of projects, initially

relatively simple and progressively more challenging as the semester proceeds. Below is a list of projects. A project will be started in class, with my guidance and explanation, as well as the theoretical background. Then the class will be divided into groups, and each group will start working on the project. Depending on the complexity of the project, you and your assigned group will usually have 1 to 2 weeks to complete the project, write the accompanying paper, and submit it. You must work on the project in class together with your group, and class attendance is mandatory. However, you should also allocate 5-10 hours a week to work on the project with your group outside of classroom.

Grading policy

Your final grade will be weighted as follows:

	Your score
Homework assignments / Projects:	100%

TO PASS THIS CLASS YOU NEED A MINIMUM OF 60%. The grades will be distributed as follows: A=90-100%, B=80-89.99%, C=70-79.99%, D=60-69.99%

IF NEEDED, THE ABOVE PERCENTILES MAY BE LOWERED, BUT NOT RAISED.

Make sure you double check your grades on the course site on Canvas from time to time, as these are the grades from which the final is computed. If there is a typo (or else), is your responsibility to alert me in a timely fashion.

Projects/Homework

One of the main goals of this course is to provide the students the opportunity to do real astronomical research while simultaneously learning about data analysis, astronomy concepts, and develop strong coding skills. These will be achieved through homework assignments and projects. Homework assignments will be mostly delivered in the first part of the course, whereas projects will constitute most of the assignments in the remainder of the course.

The students will be divided in groups of 3-4 people. Each group will have to work as a team to work through the assignment/project. Within a group, each student must actually perform each and every step required to successfully finish the project themselves. At the same time, the three members of each group are encouraged to discuss and brainstorm all difficulties and are also welcomed to develop together algorithms and pieces of codes needed to complete the projects in a timely manner. Equally allowed is the interaction between different groups to discuss the problems. It is of paramount importance though that each member of each group contributes equally to the project. Not only each student is required to submit an individual paper on each project describing the analysis and the results (see more on this below), but each member of a group will have to end the project report with a paragraph describing the contribution of the other members of the team, explicitly mentioning whether the other members have contributed in a fair manner to the project. Not contributing in a fair and equal manner to the project will be considered cheating. Copying the work or codes of others will also be considered cheating.

The project report is a very important component of the assignment, and most of the grade will be determined based on the project report. The report, which should be written as succinctly as possible, should include the following components:

1. a brief introduction explaining why you are performing the assigned project, what you will be doing, and in what sections the different tasks will be described.
2. a section describing the data or the sample in hand.
3. a section describing the analysis performed on the data or sample; this is usually the largest component of the report, and it should include the appropriate amount of figures necessary to help the description of the analysis and to providing evidence in support of the robustness of the analysis.
4. a section presenting the results.
5. a concluding section summarizing the project, and eventually mentioning ways to improve the experiment (or whether the experiment could benefit from, e.g., a larger sample).

All of the above can actually be done with Jupyter notebook itself.

The report will be graded also on the English, grammar, and spelling.

The following is a (not comprehensive) list of projects you will be working on:

a. a couple of assignments on numerical methods
b. a couple of assignments on statistics and error propagation
c. deriving rest-frame absolute magnitudes and colors of stars, and building the H-R diagram and color-color diagrams.
d. measuring the acceleration of the expansion of the universe and the amount of dark energy in the present-day universe
e. measure the velocity field and rotation curve of a galaxy
f. deriving the HR diagram for a young open cluster (e.g., M67, NGC2420, or NGC6791) and an old globular cluster (e.g., M2, or NGC5466) of stars, and fit them with stellar isochrones to derive their ages.
g. measuring the total magnitude/luminosity and colors of a galaxy
h. measuring and modeling the brightness profile of galaxy into bulge and disk
i. construct stellar mass maps of a galaxy

Work submitted late

All assignments are due at the beginning of class on the due date, or you can email me a scan of your assignment. You get 5% off for every day after the due date. Extension on the assignments are only allowed with a note from health services or an email from a dean. Maximum extension is one week.

Accommodations:

Tufts University values the diversity of our students, staff, and faculty, recognizing the important contribution each student makes to our unique community. Tufts is committed to providing equal access and support to all qualified students through the provision of reasonable accommodations so that each student may fully participate in the Tufts experience. If you have a disability that requires reasonable accommodations, please contact the Student Accessibility Services office at Accessibility@tufts.edu or 617-627-4539 to make an appointment with an SAS representative to determine appropriate accommodations. Please be aware that accommodations cannot be enacted retroactively, making timeliness a critical aspect for their provision.

Academic honesty

Tufts holds its students strictly accountable for adherence to academic integrity. The consequences for violations can be severe. It is critical that you understand the requirements of ethical behavior and academic work as described in Tufts' Academic Integrity handbook. If you ever have a question about the expectations concerning a particular assignment or project in this course, be sure to ask me for clarification. The Faculty of the School of Arts and Sciences and the School of Engineering are required to report suspected cases of academic integrity violations to the Dean of Student Affairs Office. If I suspect that you have cheated or plagiarized in this class, I must report the situation to the dean.

By attending this class you are expected to have read and understood the rules of Academic Integrity (http://students.tufts.edu/student-affairs/student-life-policies/academic-integrity-policy) and are automatically agreeing to adhere to these rules.

As advised by the Dean of Student Affairs you are required to sign a document stating that you understand these rules and will adhere to them. Sign and hand in the last page of this document you are currently holding. It is expected that students in Astronomy 51/151 will maintain the highest standards of academic honesty. In particular, it is expected that:

- During tests and examinations, you will not accept or use information of any kind from other students. You will not use aids to memory other than those expressly permitted by the examiner.
- You will never represent the work of another student as your own.
- You will never try to deceive the instructor or teaching assistant by misrepresenting or altering your previous work or that of others.
- You are allowed to discuss approach and methods with other students, but you much do your own homework and must hand in your own handwritten work. You are not allowed to copy text or phrases from other students or other sources in books, magazines, the internet, etc.

Exam Policy: Do NOT bring unauthorized materials, information, or any electronic equipment with you to a room in which an exam is being administered. Do NOT engage in behavior that gives the appearance of cheating, such as passing a note to a friend, whispering to another student while the exam is in progress, or looking in the direction of another student's work. Do NOT bring your cell phone, tablet, music device, programmable calculator or any other electronic device to an exam room. If an exam proctor sees you handling an electronic device even to silence a phone if it rings or vibrates in the middle of the exam, the Judicial Affairs Administrator will treat it as an academic integrity violation. DO turn off your cell phone and put it out of reach, out of sight, or as instructed before the exam begins.

Departures from these standards will be review with utmost seriousness by myself and Tufts University and will be reported to the Dean of Student Affairs.

HAND IN THIS PART TO YOUR INSTRUCTORS:

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It is expected that students in Astronomy 51/151 will maintain the highest standards of academic honesty. Departures from the standards specified in the syllabus and Tufts' Academic Integrity handbook will be review with utmost seriousness by myself and Tufts University and will be reported to the Dean of Student Affairs.

I understand and agree to these terms

Date:_____ Student ID:_____

Print Name:_____

Signature: _____