

AST 4932: Special Topics - Astronomical Data Analysis

Fall 2007 Syllabus

Joseph Harrington

1 Course Vitals

Room: PL 101 (SCALE-UP classroom)

Lecture: TR 10:30 – 12:00

Grading: ABCDF w/ +/-

Credits: 3(3,0)

Dates: 21 August - 29 November 2007

Final: project

Class URL: <http://physics.ucf.edu/~jh/ast/ast4932/ast4932.html>

Class directory: planets.physics.ucf.edu/~home/ast4932

Textbooks: Howell, S. B. 2000. *Handbook of CCD Astronomy*. Cambridge, ISBN 0-521-64834-3.
Bevington, P. R., and D. K. Robinson 2003. *Data Reduction and Error Analysis for the Physical Sciences*, 3rd Ed. McGraw Hill, ISBN 0-07-247277-8.
Oliphant, T. 2005. *Guide to NumPy*. At <http://tramy.us>

Recommended: Press, W. H. *et al.* 1992. *Numerical Recipes in C*, 2nd Ed. Cambridge, ISBN 0-521-43108-5.

Prerequisites: (enrollment cap: 10 total for AST4932/5937)

MAC 2313 (calculus)

A 3000- or higher-level course in astronomy or permission of instructor

Job: Lecturer

Name: Joseph Harrington

Office: MAP 420

Phone: (407) 823-3416

Email: jh@physics.ucf.edu

Hours: TR 12 – 1

2 Objectives

Those who successfully complete this course will be able to:

1. Understand basic statistics and error analysis as used in the physical sciences,
2. Extract physical measurements and error estimates from raw data,
3. Fit a theoretical model to the measurements,
4. Draw scientifically-valid conclusions from the measurements,
5. Manage and carry out online work with large amounts of data, and
6. Present scientific results.

3 Approach

We cover the following topics in roughly this order:

1. Computers, programming, online management.

2. Introductory statistics and modeling.
3. Array detectors and corrections, image analysis.
4. Measurement extraction (example: stellar photometry).
5. Fitting.
6. Spectrographs and spectroscopy.
7. Project.

4 Format

The class meets twice weekly in the computer trailer. Lecture attendance is mandatory. The weekly homework assignments are due Thursday at the beginning of class. **No late work will be accepted**, so PLAN AHEAD. Reading should be done **before** the class indicated: preparation for and participation in class discussion counts toward the final grade.

We use the SciPy Language. No experience is required, but students will need to become functional in SciPy within the first few weeks of the course.

Evaluation weighting:	
Homework	40%
Discussions	10%
Project results	25%
Project execution	15%
Project paper	10%

This is the undergraduate version of this class. Undergraduates with programming and data analysis experience may register for the graduate version, with permission of the instructor.

5 Grading

To encourage co-operation and group participation, grades will not be curved. It is possible for everyone to get an A. It is also possible for everyone to fail (but I hope not!). All reasonable questions regarding grading are welcome, but pure negotiation is not.

6 Academic Honesty, Sharing, and Information Sources

We will follow the letter and spirit of the UCF Golden Rule. Research in astronomy and physics relies on taking advantage of resources developed elsewhere: software libraries, descriptions of methods, etc. *Unless we state otherwise*, please use such external sources in your work. However, there are several conditions:

1. All math and text answers must be your original work. You may (and should) discuss the relevant general topics with each other, but you may not give specific help on or share assigned work.
2. For coding problems, the portion of the answer relevant to the problem must be your original work. For example, if the question asks you to subtract two images, you must write the code to do the subtraction but you may use third-party code to read the images from files.
3. You may not use the work of other students in the class, even if they wrote it long ago.
4. You must have legal permission to use an external source (assumed if publicly posted).
5. You **MUST** give credit to all external sources on a problem-by-problem basis. Credits must include the name of the item, a sentence fragment describing it if it is not obvious from the name, its author(s), year of authorship, and location (e.g., the name, volume, and pages of a journal article, or the URL of a software package distributed online).
6. As with any scientific research project, you alone are responsible for the output: if you download a package that claims to do something and it has a bug that gives the wrong answer, the answer is wrong and you will be marked accordingly.
7. Work you did prior to the start of the course may not be handed in for grade (talk to the instructor for exceptions).

7 Working Effectively

There will be approximately weekly homework assignments and project work. It is critical that you do the homework and readings by the beginning of class on the due date, as we discuss answers in class. Your personal understanding is what counts in the discussions, and discussions count toward your final grade. Since answers will be discussed in class, **no late homework will be accepted**.

Compared to most physics courses, this course is heavy on skills, methods, and experience. These are taught with practice on real data in the homework assignments. You should budget significant time each week to work in the lab on your homework and project. You have priority access to the lab machines for the semester. Assignments will depend heavily on prior work done in the class, so skipping work is not very useful: you'll be doing the work anyway in order to do later assignments, so it makes sense to do it in time to get credit for it. Remember that debugging can take a long time, so start your assignments early! While time spent on the class varies a great deal according to students' prior programming experience, you should expect to spend an average of 6–10 hours per week outside of class on this course.

8 Homework Answer Format

All homework questions are **electronic assignments**, unless otherwise stated, including prose answers. Math (only) may be handed in handwritten on paper, if necessary, but we prefer electronic formats. Grammar, spelling, and complete sentences count for grade, including in answers that involve math (remember that “=” is a verb). **Math** problems must show your logic and calculations. **Box or circle** final math answers.

Use plain ASCII text files wherever possible, and certainly for all program text. Other allowed formats, in preference order: FITS (for data), PDF, PS, TeX/LaTeX, Excel, MSWord (the latter two only if they work in `office`). You can convert MSWord to PDF by loading into `office` and clicking “export PDF”.

Handing in homework: Make a directory called `~/handin/hw3-jh`, substituting the right assignment number and your username. **Before class**, put the files you wish to hand in in that directory. We will copy all the assignment directories at the beginning of class automatically. **No late homework will be accepted, so be sure you actually save your files before class starts!** Do not email your homework.

For problems that do not specify the creation of new files, hand in a file of commands named, for example, `hw3-jh.py`. This should be a cleanly-coded, presentable file of commands, not a log file with other notes (note the name difference between this and a log file). In comments indicate your name, AST 4932, the assignment name, the date, and the problem numbers. We will be running these as batch files, so be sure to comment out any answers that are not commands. Also make sure all necessary program files are in the directory.

If the problem asks for a plot or image display, include commands for **both** on-screen display and output to a PostScript file. Include the files it makes in your directory. Plots should have titles and sensible axis labels, including units. Put each item in a separate file. The filenames should follow the format: `hw3-jh-prob2-plot1.ps`. *Only if requested*, put ASCII output to the screen (like tables) in files named like `hw3-jh-prob2-table1`. ASCII tables should have titles and column headers that distinguish them from one another and that make sense to the reader. You may hand-edit headers onto tables written by the computer.

9 Project

In October, each student will choose a final project based on real data. You will apply the methods learned in the course to produce a measurement and reach a scientific conclusion. There are several projects to choose from, or you may request permission to analyze some other data for which an analysis does not yet exist. Three components of the project together contribute half of your final grade: a paper, which will follow the format of the *Astrophysical Journal*, what your coded analysis routines produce (results), and how well your analysis routines are coded and documented (execution).

10 Fall 2007 Schedule

Reading and homework are due as assigned here. Lecture topics may not occur exactly on the day listed.

Date	Topic	Reading	Assignment
Tools and Theory			
Aug 21	T	Introduction, computer accounts	Lab doc
Aug 23	R	Unix/SciPy basics	Handout
Aug 28	T	SciPy graphics, Image I/O	SciPy docs
Aug 30	R	SciPy Programming, FITS data	Handout
Sep 4	T	Measurement, Probability	Bev. Ch 1,2
Sep 6	R	Error Analysis	Bev. Ch 3,4
Optical/Infrared Photometry			
Sep 11	T	Fitting	Bev. Ch 6
Sep 13	R	Array Detectors	HW4 (stats)
Sep 18	T	Detector Systematics	How. Ch 1,2
Sep 20	R	Infrared Arrays	HW5 (fitting)
Sep 25	T	Sky and Flat Field Frames	How. Ch 3-4.5
Sep 27	R	Flat Fields, FITS, Interpolation	HW6 (S/N, 2D Gaussian)
Oct 2	T	Finding & Fixing Bad Pixels	How. Ch 4.6-5
Oct 4	R	PSFs, Aperture Photometry	HW7 (dark & sky)
Oct 9	T	PSF-Fitting Photometry	
Oct 11	R	Atmospheric Absorption, Std. Stars	How. Ap C
Optical Spectroscopy			
Oct 16	T	Introduction to Spectroscopy	
Oct 18	R	Spectrum Processing	How. Ch 6
Oct 23	T	Wavelength Calibration	
Oct 25	R	Line Profiles and Blends	HW10 (spectrographs)
Oct 30	T	Interrogating Spectral Lines	
Project			
Nov 1	R	Time Series Analysis	Handout
Nov 6	T	[Another DA example from physics]	Handout
Nov 8	R	[""]	(Project)
Nov 13	T	Fourier Transforms	Handout
Nov 15	R	Fast Fourier Transform	(Project)
Nov 20	T	FFT in Practice	Handout
Nov 22	R	Thanksgiving Day: no class	
Nov 27	T	Project presentations	(Project)
Nov 29	R	Project presentations	
Dec 5	W	(in exam period)	Final Project Due