ASTP 611-01: Statistical Methods for Astrophysics

Syllabus and Course Information – Fall Semester 2017

2017 August 29

Course Information

Lectures:
TÞ 09:30–10:50, CAR(76)-1235, beginning 2017 August 29 and ending 2017 December 7

Holidays (no lecture):
Oct. 10 (Fall Break); Nov. 23 (Thanksgiving).

Instructor:
Dr. John T. Whelan; 74-2063, 475-5083; `john.whelan@astro.rit.edu`
Office Hours: M 10-11:55am & TR 11-11:55am, or by appointment

Course Website: `http://ccrg.rit.edu/~whelan/ASTP-611/`

Required Textbook:

- Gregory, P., *Bayesian Logical Data Analysis for the Physical Sciences* (Cambridge, 2005)

Recommended Additional Text:

- Sivia, D. S. with Skilling, J., *Data Analysis: A Bayesian Tutorial*, 2nd edition (Oxford, 2006)

Other possibly useful references:

- Wall, J. V. and Jenkins, C. R., *Practical Statistics for Astronomers* (Cambridge, 2003)
- Hilbe, J. M., de Souza, R. S., and Ishida, E. E. O.,*Bayesian Models for Astrophysical Data* (Cambridge, 2017)
- Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., and Rubin, D. B., *Bayesian Data Analysis*, 3rd edition (CRC, 2013)
- McElreath, R., *Statistical Rethinking: A Bayesian Course with Examples in R and Stan* (CRC, 2017)
- Wasserman, L., *All of Statistics: A Concise Course in Statistical Inference* (Springer, 2004)
- Cowan, G., *Statistical Data Analysis* (Oxford, 1998)
- Jaynes, E. T., *Probability Theory: The Logic of Science* (Cambridge, 2003)
- Casella, G. and Berger, R. L., *Statistical Inference*, 2nd edition (Brooks-Cole/Cengage, 2002)
- Bendat, J. S. and Piersol, A. G., *Random Data: Analysis and Measurement Procedures* (Wiley, 2000)
- Press, W. H., Teukolsky, S. A., Vetterling, W. T., and Flannery, B. P., *Numerical recipes: the art of scientific computing* (Cambridge, 2007)
- Arfken, G. B., Weber, H. J., and Harris, F., *Mathematical Methods for Physicists, Seventh Edition: A Comprehensive Guide*, 7th edition (Academic Press, 2012)

Prerequisites:
Graduate standing in a science or engineering program or permission of instructor.

Potential Topics:

1 Fourier Analysis
   1.1 Continuous and discrete Fourier transforms
   1.2 Spectral properties of random data

2 Probability Theory
   2.1 Fundamentals of probability theory (Bayesian and frequentist interpretations)
   2.2 Probability distribution functions (discrete and continuous)
   2.3 Specific probability distributions
   2.4 Gaussian approximation to probability distributions
   2.5 Sums of random variables and the central limit theorem

3 Statistical Inference
   3.1 Bayesian and frequentist approaches
   3.2 Hypothesis testing and model selection
   3.3 Parameter estimation and errors

Exams:
Two preliminary exams, in class, **tentatively** planned for Tuesday, Oct. 3 and Thursday, Nov 9.
Final exam (cumulative) scheduled for Thursday, Dec. 14 8:00am-10:00am, CAR(76)-1235.

Homework:
Quasi-weekly problem sets, and possibly one or more longer-term projects. Problem sets will not be accepted after solution sets have been distributed.

Course Listserv: `ast-math-stat@astro.rit.edu`
Subscribe to the list by sending email to `ast-math-stat-subscribe@astro.rit.edu`

All students will be expected to be subscribed to the course listserv from address which they read frequently, as organizational announcements may be sent there. Students are also encouraged to use the listserv to discuss concepts and issues related to the course.

I will also use the listserv to respond to student questions, so that the entire class can benefit from the exchange. If you email me a question which you don't want shared with the class, you must specify that explicitly in the email. (Similarly, if you want to ask a question anonymously, specify that you'd like your name left out of any reply posted to the listserv.)

Course Policies

Attendance:
There is no attendance grade for the course, and no penalty for missing class. However, most students will find themselves at a disadvantage on the homeworks and exams if they neglect to take advantage of the full range of tools (including both lectures and reading) to gain understanding of the material.

Exam Attendance:
Makeup exams will only be granted in extreme circumstances. Unless you have a documentable emergency or an illness which requires medical attention, you should not expect to be able to make up a missed exam. If you do have a serious illness or emergency, please contact me as soon as possible.

Class Disruptions:
Please try to avoid disrupting the class by arriving late and/or leaving early. Please silence all mobile devices if possible. In case of an urgent need to be reachable during two hours of lecture (on-call EMT, critically ill loved one, etc.), please use vibrate mode.

Collaboration:
Collective brainstorming is a time-honored tool of scientists attacking a problem, be they freshmen or tenured professors. That said, working through the homework problems is an important aid to gaining mastery of the material, and a student who simply transcribes the solution of another student or of the group will likely have trouble come exam time. In light of this, solutions which are clearly (in my judgement) transcriptions from other sources or from each other will receive reduced or no credit. You should use outside sources or group discussions as needed to get the idea of how to do a problem, then go off and write up your own solution.

Additionally, in the interest of learning proper academic procedures, you should acknowledge any outside help you get on homeworks, whether from other students or from references outside the textbook.

Working together on exams or copying off of someone else's test is of course cheating and will not be tolerated.

Grades:
Grades will be based on the following components:

25% Problem Sets
20% First Prelim Exam
20% Second Prelim Exam
35% Final Exam

Your score on each component of the course (each prelim, the final, all the homeworks together, and class participation) will be converted to a numerical "grade point" score, and the weighted average of those five scores will be your final grade, converted to a letter grade according to the scale above.

Grading Scale:

A	3.83–4.5	C+	2.17–2.5
A-	3.5–3.83	C	1.83–2.17
B+	3.17–3.5	C-	1.5–1.83
B	2.83–3.17	D	0.5–1.5
B-	2.5–2.83	F	(−0.5)–0.5

Special Arrangements for Students with Disabilities:
Students with disabilities who wish to receive accommodations in this class should contact the Academic Accommodations Office at 475-2023 or via their website
`http://www.rit.edu/studentaffairs/disabilityservices/accommodations.php`
as soon as possible so that warranted accommodations can be implemented in a timely fashion. The Academic Accommodations Office is located in SAU(04)-1150.