ASTR 475/875 Astronomical Observations
(Clemson University, Fall 2004)

Prof. Jeremy King **Office:** 302A Kinard Lab **Phone:** 656-4275 **e-mail**: jking2@clemson.edu
Class Meetings: T,Th 12:30-1:45 PM **Office Hours:** 1:30-3:00 W,1:45-3:15 Th (or just stop by)
Required Text: *None* (but see below for suggested references)

Course philosophy, approach, and goals:
Despite its innocuous sounding title, this course is a difficult one to teach. We have both undergraduates and graduate students in the course. Students in the course have a range of observing experience. Students also have a large range in their familiarity with astronomical phenomenology and background. It is likely that at times we will have students who are intimately familiar with some piece of material in the course, while others are encountering it for the first time. Thus, I surmise that a "successful" course will be one where everyone is unhappy with some part of it. But, we shall endeavour to minimise this. My approach to defining this course is as follows:

What this course is not:

- We can not complete an exhaustive consideration of observing at all wavelengths with all types of instrumentation. We simply do not have the luxury of a 2-3 semester sequence in observational techniques like that found at other institutions.
- The course will not be one aimed primarily at the physics behind observational instrumentation and techniques. I would like to minimise the abstractness of this course as much as possible, making it as useful and "hands on" as possible. Of course, we will have and take advantage of numerous opportunities to connect physics and mathematical tools with astronomical observations in the way of demonstrating applications.
- We will not build instrumentation or complete a start to finish observing project or learn all the subtle details of image processing or cover every possible technique you might someday use. First, time constraints exclude most of these goals. Second, it is assumed that specialised training in your graduate career will prepare you best for learning strategies and techniques that will be important for your own research.

What this course is:

- Coverage of topics that will have the broadest interest, prepare you for observing and analysis strategies and challenges you are most likely to encounter in the future, and provide you with sufficient background to build upon in the future.
- Material of broad and key relevance that is underappreciated or which you might not encounter in other formal coursework here at Clemson.
- Useful information that you can apply immediately to your observations, your data reduction, your analyses, and your proposal writing.
- A chance to be creative in addressing everyday questions an observer might have to answer or consider, and to force you to perhaps do some relevant exercises that you might find challenging or outside your current interests. I hope this might broaden some students' horizons, enable students to acquire some new practical skills, help students develop a critical eye concerning data, and instill students with greater confidence in their abilities.

Student Input:
While the basic themes of the course are set, and I have already outlined a broad array of material to fill the semester, I actively seek your direct input into material you would like to see covered. This course is for you! While a request like “can we learn how to flat-field Fabry Perot data?” is a bit too nitty-gritty, we could easily accommodate a request like “can we talk about the design and use of a Fabry-Perot spectrograph?”.

Course Components & Grades:

Lecture: Since we have no formal text (though below I suggest several you might wish to look at), attending lecture is important. There is no formal attendance requirement, though lectures will usually be followed by a small homework problem or two generally due by the next lecture.

Homework (33%): I encourage you to discuss the qualitative concepts behind and approaches to the homework problems together; I hope you would provide any technical help (software assistance, printing resources, etc) you can to a fellow student (particularly the undergraduates and new graduate students) who might need this. However, inspecting one another’s solutions (etc) is forbidden. To avoid misunderstandings, the usual advice I give to freshman physics students works here too: while talking to a fellow student about a homework problem, don’t have a writing instrument in hand. Please let your work be of collegiate clarity and quality. We will drop your 2 lowest homework scores.

Exercises (32%): I will frequently assign more involved (not necessarily particularly difficult) exercises that let you apply techniques to an astronomical problem with some reflection about the results. The more involved aspect might come from some mild numerical analysis, or writing a bit of code, or extracting and examining a dataset from the literature, etc. The deadlines will be a few lectures longer than for homework exercises. You may be asked to share your results with the rest of the class. A variety of these will be assigned, but you will be allowed to choose which you carry out. G*raduate students should attempt* ***four (4)*** *exercises, and undergraduate students should attempt* ***three (3)*** *exercises.* If you hand in more, I’ll simply keep the 4 or 3 with the best grade.

In-class presentations (15%): Students will each give 2 short (15ish minutes) in-class presentations on topics related to the course. These are intended for all of us to learn from, so they should be informal (though illuminating). I will simply designate a topic and date and student from time-to-time. If this falls at a bad time (during the day of a mid-term in another course or when you might have to be away), please speak up. ASTR 475/875 is a benevolent dictatorship and we can be flexible.

“Final Exam” (20%): *Graduate students* will write an observing proposal for the Kitt Peak National Observatory 4-m telescope. This will be completed using the real NOAO online proposal form, and conform to NOAO guidelines. While the proposal can be to carry out any observations of any object using any available instrumentation you’d like, the scientific merit and clarity of the proposal will be considered. Hard copies or PS/PDF files will be due the final week of class. The proposals will then be disseminated to the entire class, and assigned to an undergraduate primary reviewer and a fellow graduate student secondary reviewer. During the Final Exam period for a T,Th 12:30-1:45 class, we will all meet as a Time Allocation Committee and discuss/vote on the proposals (the proposal author will be absent during deliberations and voting on his/her proposal). For graduate students, I will base Final Exam grades on a) your review of your assigned proposal, and b) my own review of your own proposal after hearing your peers’ comments. I will base Final Exam grades for the undergraduates on their review of their assigned proposal and their final written comments on the proposals for which they serve as lead reviewer.

Course Resources: An exhaustive list of all course resources that might be of great use is simply too long to list here. But a fairly complete list of some very good ones that provide great starting points is as follows:

Observing Techniques Texts
§ *Astrophysical Techniques*, C.R. Kitchin, 3rd edition, Institute of Physics Publishing
§ *Astronomical Observations*, G. Walker, 1987, Cambridge University Press
§ *Astronomy Methods*, H. Bradt, 1st edition, Cambridge University Press
(The first two are standards; original versions had a not insignificant number of errors when I was a graduate student, but I believe these to be cleaned up in the Kitchin text. In my opinion they provide an ok and wavelength-complete introduction—but one that is stunted and very superficial. The last text by Bradt is the newcomer, and looks quite promising, providing an astrophysical phenomenology-driven approach to methods).

Specialized Texts
§ *Detection of Light*, G. Rieke, 2nd edition (2002), Cambridge University Press
§ *Handbook of CCD Astronomy*, S. Howell, 2000, Cambridge University Press
§ *Astronomical Optics*, D. Schroeder, 1987, Academic Press
(The Schroeder text is slim and concise, yet rigorous. As an overview of astronomical optics, it is without peer. The small Howell text is destined to become a classic must-read).

Statistics Texts and Resources
§ ***Data Reduction and Error Analysis for the Physical Sciences***, P. Bevington, 3rd edition (2002), McGraw-Hill
§ *Astrostatistics*, G.J. Babu & E. Feigelson, 1996, Chapman & Hall
§ *A Practical Guide to Data Analysis for Physical Science Students*, L. Lyons, 1991, Cambridge University Press
§ *Kendall's Advanced Theory of Statistics*, M. Kendall & A. Stuart, 6th edition (1998), Arnold Publ
§ http://fonsq3.let.uva.nl/Service/Statistics.html (web-based statistical tests)
(The Bevington text is a **true** classic that should be on every student's shelf. If you don't have it, check your pulse, then buy it. In my opinion it is far superior to the overlywatered down text by Taylor that is popular in undergraduate physics. If you are looking for the gold standard in mathematically rigorous and complete treatment of statistical theory, then you will pony up some $$ for Kendall & Stuart's 3 voluminous (each of order 700 pages) volumes.)

Analysis Text and Software
§ *Numerical Recipes: The Art of Scientific Computing*, W.H. Press et al., 2nd edition (2002), Cambridge University Press (the code can be purchased/downloaded at www.nr.com)
§ *SM* (this plotting and analysis package lives on the CoES Unix server)
§ IRAF (this image reduction, observing/analysis tools package lives on the CoES Unix server and the linux boxes in the SARA room)
(The Press et al. text/code is the Bible of numerical techniques and statistical codes a data intensive person might utilize. The text gives concise simple explanations of the code and the background methodology. The code is available in C, C++, FORTRAN 77/90 for Windows, Linux, Unix, and Macs)

Web-based information resources

§ SIMBAD database   http://wimbad.u-strasbg.fr/Simbad   If it's an astronomical source or object, you can find most relevant details and complete bibliography in this vast searchable database.

§ NASA ADS http://adsabs.harvard.edu   Search for (and download) astronomy/physics/geophysics papers by year, author, title, subject, keyword, etc from this award-winning database.

§ LANL Preprint server http://xxx.lanl.gov/archive/astro-ph (search for real preprints, people's trial balloons, some entertaining "original ideas", and unreviewed self-published works here).