AS 441 – Observational Astronomy

Prof. Dan Clemens – Spring 2015


Meeting Times: Lectures: MWF 11-noon, CAS 500; Computer Labs: Fridays noon-1pm, in CAS 606; Observatory: 6-10pm, Wednesday Evenings, in CAS 606

AS441 Office Hours: Mondays and Wednesdays 9-10am, in room CAS 417, and by appointment (3-6140; clemens@bu.edu)

[can also come to AS802/803 office hours, though those students have priority then - Mondays and Fridays 1-2 pm in CAS417]

Synopsis: This course is the capstone course for Astronomy and Astronomy-and-Physics majors, normally taken at the end of their Junior or Senior year. The course will emphasize: (1) introduction to observational techniques, including photometry, imaging, spectroscopy, polarimetry, and interferometry; (2) development of error analysis skills, including basic statistics and regressions; (3) problem solving in analytic, computational, and telescope+detector systems; and (4) effective scientific writing through project reports.

This course represents a departure from previous courses (which emphasize lectures, homeworks, and exams) by encouraging students to research, design, develop, debug, and explore all aspects necessary for conducting quantitative astronomical observations. It will be strongly “hands-on” and will utilize a great deal of the understanding developed in previous courses (especially AS202, 203, 311, 312, and 413).

This semester we will use the small radio telescope, the computer-controlled 14” telescope and CCD imager, and the Mimir infrared instrument on the Perkins telescope in Flagstaff, Arizona.

Texts (Required):


“An Introduction to Programming with IDL,” by Bowman. ISBN 978-0-12-088559-6


Attendance & Absences: The lecture meetings (MWF 11-noon), computer discussion meetings, and observatory sessions are all vital components of the course – every meeting should be attended by every student. Chronic absences and/or late arrivals negatively impact other students.
in the course and are to be avoided. Any student missing from, and/or late to, more than 20% of the lecture meetings will be failed in the course.

The discussion sessions will be a mix of some lectures and some practical instruction in computer use or telescope/instrument use.

Operating the rooftop telescopes to conduct astronomical observations is a required component of this course. Students will coordinate their schedules in order to meet the observing needs of their group observing efforts while allowing for the safe execution of the observations and the transport of students to and from the observatory. A reasonable “average” observing time load to expect during the semester is about 2 hours per student per week. Students who fail to operate the telescope/instrument system for the completion of their observing projects will fail the course. It is my intention to be present most clear Wednesday evenings from 6-10pm to assist with observatory checkout and data collection. Students are encouraged to use the available other nights to complete their observing projects, as needed.

**Grading:** The course grade will be computed by weighting your performance in the following areas by the percentages listed:

<table>
<thead>
<tr>
<th>Course Component</th>
<th>Percentage Weight</th>
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<tbody>
<tr>
<td>Lab Reports (4 expected)</td>
<td>40%</td>
</tr>
<tr>
<td>Homework (7 expected)</td>
<td>16%</td>
</tr>
<tr>
<td>Midterm Exam (48 hr take home)</td>
<td>12%</td>
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<tr>
<td>Oral Presentation (1 expected)</td>
<td>10%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>12%</td>
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<tr>
<td>Attendance and Participation</td>
<td>10%</td>
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**Late Policy:** In the real world, missing deadlines has dire consequences (e.g., failure of a NASA mission to launch on time could make it unable to answer the questions it was designed to address – representing a tremendous waste of taxpayer dollars). Since we are practicing for the real world in this class, and trying to instill the highest work ethic, the late policy for homework and reports this semester will be equally dire. Failure to turn in an assignment on the designated date, by the designated time, in the designated format will result in a loss of 15% of the total value of the assignment for each calendar day the assignment is late.

**Homework:** Homework will allow students opportunities to practice computer programming, spreadsheet programming, error propagation and statistics, as well as other aspects of observational astronomy.

**Lab Reports:** In many professional fields including astronomy, an enormous emphasis is placed on strong writing and communication skills. In order to foster the continued development of good writing habits, this class will contain a significant writing component in the form of observing and project reports. The required components and format details may be found by clicking the "Lab Reports" link at left.
**Conduct Standards & Collaboration:** In this course, students will work in a variety of settings from pure independence, to small groups, to larger groups. It is important that students submit for evaluation work that is properly executed and attributed. I encourage you to study together, but to write up and submit your homework assignments and reports separately. You may help each other to find how to solve a problem, but you must present your own discussion of the steps needed to achieve the solution. Do not copy from another student or from another student’s work (including students not in this class).

*Data may not be shared between project groups*, unless such sharing is specifically allowed by the instructor. *Data from the telescope/instrument shall not be manufactured* or simulated, expect as part of specific exercises or projects.

Students are reminded that their behavior is governed by the CAS Academic Conduct Code, copies of which are available from CAS 105. I am required to state that cases of suspected academic misconduct will be referred to the Dean’s Office.

**Midterm Exam:** There will be one 48-hour take home Midterm exam to be handed out on Monday, March 2nd

**Final Exam:** The final exam will take place from 12:30-2:30pm on Tuesday, May 5th. It will be closed book, and cover all material in the course. Note that the final exam is not at the usual class meeting time. Also note that the final exam time and date cannot be changed for anyone, as per university rules.

**Lab Projects Schedule:** The lab schedule that follows may be modified, depending on sky and equipment conditions, but students should hearken seriously to the lab report due dates listed.

<table>
<thead>
<tr>
<th>Lab Project Name</th>
<th>Tools, Wednesdays Covered, day or night status</th>
<th>Lab Report Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Night Sky Brightness</td>
<td>14” Celestron + CCD 1/28, 2/4 rooftop nights</td>
<td>Fri, 2/20/2015</td>
</tr>
<tr>
<td>2. CCD Characterization</td>
<td>14” Celestron + CCD 2/18 (primary), 2/23 (backup) rooftop nights</td>
<td>Fri, 3/20/2015</td>
</tr>
<tr>
<td>4. Radio Telescope Beamsize, HI Cloud Map</td>
<td>Small Radio Telescope 4/1, 4/8 rooftop</td>
<td>Fri, 5/1/2012</td>
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</tbody>
</table>
Presentations: Oral presentations are an important aspect of modern astronomy and professional technical management. You will give one, 10 minute presentation (with up to an additional 5 min for questions) to the class near the end of the semester. The topic will be an instrument of your choice, one not discussed in class and chosen in consultation with Professor Clemens. Powerpoint presentations are preferred, and should be prepared with the finest quality and using proper attribution. More information about the presentations will be provided later in the semester.

Computers, Computer Programming, Computer Programs: We will use a variety of computer-based tools during the semester. These include the computer and programs that control the 14” telescope and CCD, the computer and program that control the Small Radio Telescope, the computers and programs that control the Perkins telescope and Mimir instrument, the data reduction and analysis computers in CAS 606, as well as your own home computer.

The computers in CAS 606 are used by AS441, AS203, and AS802, and may be used in a more limited fashion by AS102. During our computer discussion time slots, AS441 has priority use of CAS 606 computers. At all times, AS441 students have priority use of the computer in the outer room of CAS 606 (the “observing room”) and in the “old 14 inch dome” on the rooftop. At other times, AS203 may have priority use of the computers in the back room of CAS606. This is normally expected to be in the 4:30-6pm time slot. At other times, AS441 and AS203 students may share use of the computers in the back room.

Computer programming is an essential skill all astronomy students should have. Exposure to image analysis is another key skill. We will attempt to meet the first goal by learning the Image Display Language (IDL), and we will meet the second goal with a combination of IDL and MaxIm DL, the program we will use to operate the CCD camera.

You will also want to use Excel or a similar spreadsheet program to perform high-level analyses of your data sets, including linear regression, averaging, and simple statistical analyses.

Lectures: The lectures will be ordered to try to present key concepts in advance of their use in the lab exercises. Thus we will begin learning about basic statistics and error analysis prior to the first lab, then build on our understanding by learning about different statistical populations (Poisson, Gaussian) prior to the second lab where these concepts will be applied. Similarly, we will learn about linear regression (line fitting) and convolution before the spectroscopy lab, and function fitting before the radio telescope lab.

Exceptions to Normal Meetings:


No Lecture or Computer meetings on: 2/16 (Holiday - Lecture will be on 2/17), 2/27, 3/6, 4/20 (Holiday), 4/22, 4/24
Goals, Hopes, Aspirations

1. Become conversant with basic error analysis and propagation
2. Conduct real, quantitative telescopic observations and experiments
3. Write comprehensive lab reports in good scientific writing style
4. Conduct quantitative image analyses
5. Write useful computer programs
6. Make oral presentations of a scientific nature
7. Perform quantitative photometry
8. Perform quantitative spectroscopy
9. Learn about the signal-to-noise ratio and its relation to the economics of astronomical observations
10. Be exposed to the concepts of convolution, deconvolution, and Fourier analysis
11. Perform function fitting to real data
12. Be exposed to optics concepts and optical designs
13. Practice data mining