Instructor: Steven Majewski, Office=Astronomy Building (AST) 251B, email=srm4n,
Phone: 4-4893 (work), 975-6435/825-1171 (home/mobile – observatory emergencies only).

Office Hours: Fridays 4-6PM, after class, or by appointment. Note that I am often in my
office afternoons and evenings.

Teaching Assistants (TAs) – office hours by appointment:

- Luca Beale, Office=AST 224, Phone=4-7933 (office), 716-698-3494 (cell), email=lb5eu
- Nick James, Office=AST 263, Phone=3-8941 (office), 339-927-3304 (cell), email=njj5pn

Course Description: This course has two main parts, lectures and observational projects;
both emphasize astronomical observing and data analysis with a focus on “active learning”.
In the lectures you will learn background material needed to understand the night time sky,
telescopes and modern observational techniques and equipment and prepare you to (1) plan
and make astronomical observations using a variety of modern instruments, (2) reduce the
data you obtain, and (3) understand and analyze the results.

At the observatory, during labs, you will put these techniques into practice. Most of your time
for this class will be spent: (1) at the telescopes (at night), (2) reducing and analyzing your
data (day or night in the Computer Lab), and (3) formally reporting on your results. You
will use equipment at the McCormick Observatory, including the historic 26-inch refractor, as
well as modern instrumentation (e.g., CCD cameras, spectrographs, computers). Depending
on how the semester schedule unfolds regarding weather lab assignments and the weather,
we will conclude with experiments using research-grade facilities at Fan Mtn. Observatory
and/or with the Apache Point Observatory 3.5-m (in New Mexico). Even if you do not
become a professional astronomer, your skills in careful observation, and interpretation and
analysis of data will be useful in many fields. The skills you will learn in this class may also
put you at an advantage if you should apply for Research Experience for Undergraduates
(REU) programs, since many undergraduate programs at other universities do not include
hands-on experience with data collection and reduction at the level you will have in this
class. UVa students traditionally have had good success getting into these programs.

Lecture Time & Location: 11:00AM. – 12:15PM in T,Th in ASTR 265.

Lab Preparatory Sessions: T, W 9:00-11:00PM in ASTR 265.

Laboratory Work: Due to the vagaries of weather, this class cannot operate with fixed
lab times. The official “Lab Time” listed above and on SIS will be used to introduce you to
equipment and concepts needed to do lab work, but you will almost always be working on the
labs outside of those hours. Substantial tenacity, initiative, flexibility and time commitment
will be required from you to maintain the lab assignment schedule. It is imperative that
you keep close watch on the weather, plan to take advantage of clear skies, and plan for backup clear nights, because Virginia weather can be very capricious. Much of our work will take place at McCormick Observatory, which can be scheduled for other events (like Public Nights); so planning and requesting observatory access as early as possible is recommended, especially if you want to work in prime evening hours.

**Computer Lab:** You will also have 24 hour access to the computing facilities set up for you in the computer lab in AST Room 213. However, you will need a ZA4 building key to open that room or to get into the AST building after normal hours (which are 6AM–7PM).

**Time Commitments:** This is a four hour laboratory class geared for third and fourth year astronomy and astronomy-physics majors; thus, you should expect this class to take more time, and be more demanding, than other classes you probably have had. *It is important that you understand the time commitment for this class and evaluate whether your semester schedule will accommodate such a commitment.* The night work in this class will require significant investment and a flexible evening schedule to be ready to exploit clear skies when they are available. While demanding, this class will probably prove commensurately more rewarding as well. For many students, ASTR 3130 provides the first opportunity to experience what real observational/research astronomy is like.

**Prerequisites:** This course is designed for third-year Astronomy/Astronomy-Physics majors. By this time majors should have completed introductory Physics and Calculus sequences, have had exposure to computer coding, and have familiarity with basic statistics. If you do not have this background, you must discuss your situation with Mr. Majewski as soon as possible and obtain permission to take this course. This course should not be considered as an option for fulfilling a 3000-level elective for the Astronomy minor unless you are truly fascinated with learning the details of quantitative astronomical observation (said another way, this course is much more work than the average 3000-level astronomy course).

**Class Web Pages:** The class home page is [http://faculty.virginia.edu/ASTR3130](http://faculty.virginia.edu/ASTR3130). Here you can find most of the important information about the class, including links helpful for doing lab work and other useful reference material. In addition, some lecture material for this class can be found on the class website. This material is provided as a service to the students because: (a) The class often requires interpreting complex figures that are too tricky for me to draw on the board and equally difficult to copy into notes quickly. (b) I can make use of sky animations and other “web videos” to illustrate complex concepts. (c) Much of the material I present is not in any one textbook, indeed, some is not in any textbook at all. (d) It gives a guide to the organizational aspects and important themes of the class.

**WARNING:** The web lecture notes are not a substitute for attending lecture. You are expected to use the web lecture notes as a resource to, not a substitute for, attending lecture. The class is small enough that non-attendance will be obvious and noted. Some lecture material will not be on these web pages, so it is essential to attend lectures to keep up.

**Text and Supplies:** There are no textbooks that match well the range of topics covered in this class; I am currently writing that book and may from time to time hand out chapters
for you as reference. In the meantime, the new edition of *Observational Astronomy* by D. Scott Birney, Guillermo Gonzalez & David Oesper does a reasonable job of matching the course material. Copies of Birney et al., as well as *To Measure the Sky* by Chromey, can be found in the grey cabinet in the Computer Lab (AST 213). We will also use *Data Analysis for the Physical Science Students* by L. Lyons, however I did not order this from the book store because the price charged to you is outrageous. I suggest that you buy a used copy on Amazon or other on-line used book dealer. A copy is on reserve in the Astronomy Library. Over the course of the semester, other useful reference material may be placed on reserve there. Note that reserve books should not leave the library.

Finally, an on-line version of the *Astronomy 3130/5110 Observatory Handbook* is here: [http://people.virginia.edu/~mjn4n/obsmanual.html/index.html](http://people.virginia.edu/~mjn4n/obsmanual.html/index.html) (linked from the class home page). It is recommended that you print out chapters as you need them to use for telescopes and equipment needed for each lab. HOWEVER, do not use the department printing facilities for this! If you wish a printed copy please use your own resources.

You will need a flashlight (preferably one that has a red filter). The best option is a headlamp with a red filter option. Alternatively, the MagLite can be purchased with red filters and also a convenient belt holster for that nerdy, but prepared look.

You are strongly encouraged to purchase a bound lab notebook (not a looseleaf spiral pad) for keeping in one place your data and reduction notes from the telescope and day lab. This is an important habit to develop as scientists, and it will pay dividends to start that now.

**Assignments:** This is a lab course designed to give you experience with important techniques of astronomical measurement (e.g., imaging, photometry, spectroscopy, etc.), and the work will center on your observational experiments at the observatory. You will conduct these experiments in much the same way that professional astronomers do observational research. Thus, you will be expected to prepare for the observations in advance, make a request for telescope access, keep observing logs and detailed notes of your work at the telescope, and then prepare a report in the style of a “published paper” of a professional astronomer, including: a description of the purpose of the experiment, presentation of the data (including a copy of the observing log) and its reduction (including images and plots), analysis of the data (including calculations used), and a discussion of the outcome/conclusions of the experiment. In addition, each lab also has a set of questions that you are to answer. Mark clearly in your reports where you put the answers to these questions.

There will also be periodic homework assignments in this class, in addition to, or in support of, the labs. “Prelabs” must be completed to get access to the telescope. Other assignments should be handed in at class time. There will be penalties for work turned in late; I reserve the right to not accept work beyond the deadline.

**Schedule and Deadlines:** There will be roughly six lab assignments this semester (including a “final project”) depending on the weather; therefore you should expect that labs will be due roughly every two weeks. When periods of consistently poor weather prevail that make it hard for anyone to complete the lab, we will extend deadlines. However, this will NOT
be done if we believe there were enough clear nights to complete the work, whether or not you elected to use them. Labs will be due at the beginning of class on the due dates. Other assignments will be interspersed between lab assignments with deadlines clearly marked.

**Grades:** The course grade will be based on an accumulation of points. Because this is a lab course, the majority of your grade will be based on your lab results and write-ups. Labs will have a point value ranging from 100 to 200 points, depending on complexity. There will also be a midterm, which will be worth approximately one lab in points. Prelabs and other assignments will have smaller point totals (prelabs will have roughly 10% the value of the labs). Grading and scaling of grades (if necessary) will be such that the final grades will map fairly well onto a 90-100 = A, 80-90=B,.... grading system.

**Signing Up For Telescope Time:** You will need to sign up in advance for telescope time by making a specific date/time request to the TAs. The TAs will then check the observatory schedule as well as their own and either confirm your request or negotiate with you an alternative. To ensure that clear sky telescope time is equitably shared, the standard time allotment will be limited to two hours per group. However, if there is no other conflicting demand, this can be extended at the discretion of the TA. Should the semester be particularly encumbered by poor weather, we reserve the right to alter the time allocation/reservation policy. Please remember that the TAs have their own classes and commitments, and may not be available on short notice for observing time that has not been pre-arranged.

**Computing:** The primary PC computers for this class are located in Room AST 213. They are kept up to date with the 3130 software. You will be introduced to these computers and the software later in the semester. In the /net/astro_owners/astro3130 folder there will be subdirectory folders for each group in the class. These areas are for you to store data taken with the CCDs. Make subdirectories for each lab experiment, to keep things organized. Note: The disk space allotted for you is intended for storing, reducing and analyzing your data, or to prepare the reports on your observing exercises. *The computer access given to you is intended only for ASTR 3130 work. Do not abuse it.* When using the department computer please exercise the usual security protocols regarding passwords (do not give them out!) and unattended login sessions (do not leave computer without logging out!).

**Weather Conditions:** Your ability to complete work in this class will depend heavily on the availability of good weather, and, in some cases, on the brightness (phase) of the moon. You must remain cognizant of weather conditions and forecasts and be prepared to observe if the weather improves unexpectedly. There are numerous available websites (linked from the course webpage) with satellite imaging maps and forecasts that you can use in your planning. A prediction of sky clearness and darkness can be found on the “Clear Sky Clocks” link on the class home page, and at 7:30 PM each day one of the Astronomy Deptartment TAs for the lower division classes leaves a phone message regarding the weather and the status of the observatories for those classes at 924-7238. While you may avail yourself of this late afternoon telephone prognosis as well as the Clear Sky Clocks, remember that predicting changes in conditions is difficult and unreliable and that you are ultimately responsible for
tracking them. Poor weather will NOT be accepted as an excuse for assignments turned in past the established due dates (see below). Only in the case of consistently poor weather will due dates be renegotiated, at the discretion of the professor.

**Keys:** You will need a ZA4 key to gain access to the Astronomy Building, the Astronomy Library, and the Computer Lab. Keys can be obtained from our department secretary, Ms. Jackie Harding. There is a $20 returnable deposit on keys.

**Organization of Your Time:** It is worth repeating that this course requires substantial initiative and diligence on your part to plan your observing schedule carefully to make use of **EVERY** clear night, starting from the very first week of classes. We will do our best to make sure that each student or group has an equal chance to get “prime time” hours throughout the semester, as long as requests are made sufficiently in advance. Obviously, we cannot guarantee the weather, and signing up for a time slot that gets weathered out does not alleviate you of your responsibilities to get observing work done.

It often takes more than one observing session to complete an observing exercise. Given the demands on the department telescopes, you will probably even need to use unusually late hours (e.g., past midnight) or weekends to complete your work. You should not take this course if you have a night job or other commitments that prevent you from observing. Bad weather will not be accepted as an excuse for incomplete work, and you will receive only minimal credit if you have completed your observations but have not analyzed them. **While the lab assignments will be typically be due every two weeks, you should make sure to spread the work out over the full two weeks to avoid last minute crises and having your labs assignments for this course impacting your homework in other classes.**

**Group Work and Honor Code:** For much of the observing and reduction work you are encouraged to work in lab groups of three people. **Groups larger than three people require prior approval of the TA.** You will learn most effectively in this course when you work closely with others, especially when you understand something and instruct one of your fellow students. Such collaborative work is encouraged and highly valued. HOWEVER, lab write-ups are your personal work. You will acquire the data in a group and likely team for the analysis of that data, but, **unless otherwise announced**, you will be responsible for writing up and turning in your own lab report. It is a key objective of this course that your develop your presentation skills. We will provide lab write-up guidance with the first lab to provide pointers on our expectations for good format. The day assignments and pre-lab assignments are meant to be individual assignments unless otherwise indicated.

Each lab experiment requires different data, skills, reduction procedures, analysis, etc. and what is expected as group work and as individual effort may be expected to vary. We will try to make clear with each lab any variations in where lies the dividing line between group and individual work, but, IF EVER IN DOUBT, PLEASE ASK. Groups should use the following general guidelines (exceptions will be noted in the lab assignments):

1. You may observe as a group if you keep track in your observing notebook and on the observing logs who was present each night and when. Due to the nature of the projects in
this class, which often involve collecting one set of data shared by all members of the group, it is expected that you keep the same members of a group together until the observing for each experiment is fully completed. One observing log may be kept for the entire group each night, but each member should include a copy of that log with their reports.

(2) The responsibilities of finding objects with the telescope and operating instruments must be shared equally, with duties traded throughout the observing. By completion of Lab 3 every student is expected to know how to operate the telescope and find objects on their own.

(3) In the case of some labs involving the collection of data with computerized equipment, at the end of each night of observing at least two copies of the data should be saved and kept by different members of the group. This is important not only to allow multiple avenues of access to different members of the group for independent work with the data, but to ensure that backup copies of the night’s work are preserved. Each member of the group should also obtain their own copy of the observing log for the night’s observations.

(4) In most cases (exceptions will be noted), post-observing reduction of the data (e.g., using computer analysis software) may also be done as a group (no more than three people), as long as the reduction duties are shared equally among the group members. It is safest and best for you if each group member saved their own versions of final, computer-related products (plots, datafiles, images, tables) to have them available for writing up their own lab reports.

(5) Once observations have been obtained and reduced, each person in the group should write his or her own report independently (i.e., in your own words). You may discuss the results and interpretation of the data with each other, but your lab report should reflect your own assessment, assembly, and description of the data, reduction, analysis and conclusions. In general, the rule to follow is that anything involving the creation or manipulation of an image, video, spectrum, or table of data values will be allowed as a group activity, and most things involving the creation of plots, prose, computer programs or requires the calculation of quantities is an individual effort. Any collaboration should be indicated in the lab report.

(6) If you decide to reobserve, remeasure or reanalyze any data because of some disagreement with members in your group, your report should include a statement of what was wrong and your reasons for redoing the experiment.

Safety and Responsibility: There are many unavoidable hazards associated with an observatory: working in the dark, heavy equipment, hanging cables, etc. Be very careful. It is imperative that you work with the utmost of care, patience, common sense and forethought. In the dark move slowly and cautiously. Read all instructions carefully and thoroughly, and then obey them. They are for your protection and for the safety of the equipment. Always carry a flashlight, and NEVER OBSERVE ALONE.

The telescopes and equipment that you will use in this course are delicate, expensive, and sometimes priceless and irreplaceable. They are also used for a number of undergraduate and graduate courses, and, in some cases, for research by faculty and their students. Breakages will affect not only your fellow ASTR3130 students but a wider pool of users. NEVER force any moving part beyond reasonable and expected resistance. Never move the telescope
by pushing on the mounted instrumentation (CCD, spectrograph, etc.), and never lean or support yourself by holding onto the equipment. If you suddenly get confused or entangled in the dark, freeze and ask for a light and assistance. Do not yank on cables because this will break connectors or pull equipment or computers onto the floor.

Optical elements, in particular, are very delicate and expensive. NEVER touch any optical element. Oils from your skin can permanently mar glass surfaces and optical coatings. It is preferable to leave dust on optical surfaces rather than risk scratching the surfaces with attempts at cleaning. If the dust seems to you intolerable, let the TA know the next time he/she is available. If you are in doubt about how to operate a piece of equipment, you should consult the TA. THINK BEFORE DOING.

To minimize the potential for accidents, and to make most efficient use of your observing time, read all lab instructions and relevant manual pages and prepare finding charts and coordinate lists in the daytime before you head to lab. Make a plan of your activities and have a clear idea of your observing strategy for the evening, including the hour angles/airmasses of your targets at the time you intend to observe them. High airmass observations (i.e., observing objects near the horizon) should be avoided for both scientific and safety reasons. Lab time with clear weather, especially when the TA is available, is extremely valuable. If you take the time to plan out the evening in advance, then you can concentrate on your project during the observing session, when telescope and TA time is precious.

Always double check the safety of the equipment before you move the telescope, close the dome/roof/shutter, etc., and be especially careful about opening and closing the telescope and dome during your observing session. Because the telescope will be tracking, you must not only be aware of where the telescope is, but where it will be throughout the time you observe any particular object. Collisions of the telescope with the pier, ladders and any other objects in the dome MUST be avoided. If something breaks or jams, do not attempt to fix it yourself! Contact the TA or professor immediately.

TA Hours: The TAs are paid for only a specific number of hours to assist with this class. Moreover, they have their own classes, research and departmental work to worry about throughout the semester. Please respect their limitations and schedule. Do not make your deadline emergencies their problem.

Calling for Help: On occasion you may be working with no TA or professor present. If this is the case and you have a problem with a piece of equipment, first make sure you have followed all procedures correctly. If this still does not help, only then call the TA for assistance. In the case where people, equipment or the observatory are in imminent danger (e.g., telescope stuck in a dangerous position, dome slit frozen open) you MUST make every effort to contact a TA (first), Mr. Majewski (second), or any other faculty member or graduate student immediately. Mr. Patterson lives near McCormick and may be a person to call for an emergency situation with the facilities (971-7103). Obviously, in the case of a medical emergency, call 911 first. Please exercise judgement: The safety of people and equipment should be your highest priority, and if you believe there is any risk, you should take appropriate steps to take care of the situation.
LOSS/BREAKAGE AND SAFETY AGREEMENTS

Loss and Breakage Agreement

The equipment you will use in this course is fragile, expensive and difficult to replace. So that everyone has equal opportunity to complete the course requirements and that responsibility for any breakage can be assigned fairly we have implemented the following loss and breakage agreement.

1. You are on your honor to report all damage to the instructor or TA immediately. Do not attempt to fix it yourself. Shut down the equipment and report the problem. If the nature of the damage endangers other equipment (roof won’t close, electrical problems) you must contact us. If neither the instructor nor the TA can be reached, contact any astronomy department member.

2. Damage caused by the student will be assessed against you. In the case of loss or damage that cannot be assigned as the responsibility of a given individual, all students authorized to use the equipment during the time period in which the problem occurred will share equally the cost of replacement or repair. Checks on the equipment are made daily and the last users will be held responsible for its condition. If an item appears damaged or is missing when you first check it out, notify your TA so that the previous users will be assessed damages.

3. Always fill out the telescope log for every observing session. The 26-inch has a log book on site wherein you are to record your use of the telescope. No credit will be given for observations carried out during an unlogged session.

4. In all cases the judgment of the Astronomy Department in assessing the damage costs is final. We will make every effort to be fair subject to the constraint that the costs must be paid. Normal wear will be allowed for. All assessed costs must be paid within 4 weeks of notification. Your grade will be withheld until all payments have been made.

Safety Agreement

This is a laboratory course and like any lab course there are potential hazards that could result in injury. For the most part you will be working in the dark and outdoors. Use common sense when moving about; do not make any sudden, quick movements. Telescopes have sharp corners and parts that stick out. Make a mental note of the locations of all equipment, including steps, ladders and power/data cords. This information may help you to prevent accidents. In any event, always carry a flashlight. Remember that you are more likely to hurt yourself than large pieces of equipment!

McCormick Observatory  Much of your observational work will be done here using the 6-inch and 10-inch telescopes in the Doghouse and the 26-inch in the main dome. Some safety notes:

1. The instruments and telescopes have electrical connections. Be alert.
2. Watch your footing in the Doghouse. No horseplay. **No alcoholic beverages** and no food of any kind near the equipment. No smoking.

3. First-Aid equipment is located in the alcove between the dome room and the lobby. There are several phones in the building. Note their locations.

**Fan Mountain:** Any trips to the Fan Mountain Observatory will be supervised by the TA or faculty. It is always about 10 degrees colder at Fan, so you will need to dress extra warmly.

**Injuries:** If an injury of any kind occurs, notify the TA or instructor if he or she is present. If the injury is minor and no supervisor is present, you should notify the instructors the next day. If the injury appears even remotely serious call the rescue squad (911). Notify the instructor **immediately.** (Call him at home if necessary.)

Wear suitable clothing at all times. Remember than even 60 degree weather can be chilling if you are engaged in observing outside with a minimum of movement.

Metal surfaces get very cold; numbed hands can lead to accidents. Walk slowly and carefully when leaving a lighted room and entering the dark. It takes a minimum of 5 minutes for your eyes to adjust reasonably back to darkness and more than a half hour for full adaptation. Once your eyes are night adapted, it is best to keep them that way until all observations are completed. Repeated switching from light to dark will cause eye strain.

After reading these agreements, sign the pledges on the next page.
LOSS AND BREAKAGE AGREEMENT

I understand the loss and damage policy described elsewhere and agree promptly to pay replacement or repair charges assessed me by the Astronomy Department. I will report all problems in the manner prescribed as quickly as possible.

Signature: ____________________________

SAFETY AGREEMENT

I understand the policy regarding safety for this course and will act responsibly to prevent accidents.

Signature: ____________________________

HONOR CONTRACT

I have read the syllabus for ASTR 3130, have had an opportunity to ask questions about the requirements of the class and expectations regarding pledged, implicitly pledged and group work, and understand the honor policies in the class.

Signature: ____________________________

ID#: ____________________________ Date: _________________
ASTR 3130 Information Sheet

This information helps the instructor to plan the classes. It is helpful to know your level of astronomy education and your intended career path. Please return to the instructor.

Name (print): ____________________________ Email: ________________

Major: ____________________________ Phone: ________________

What is your background in observational astronomy? (e.g., amateur astronomy, REU experience, astronomy club, ...)

What is your background in physics and astronomy generally (e.g., “majoring in physics now”; note that the last question below asks for previously taken course listings)?

What is your primary reason for taking this course (e.g., required for major, recommended, heard it was an easy grade)?

Post-graduation plans (e.g., high school science teacher, science writer, graduate school in astrophysics to become PhD research astronomer, career unrelated to astronomy/physics):

What computer operating system do you know (e.g., MacOS, Windows)? Which do you prefer to use?

What computer programming languages do you know (e.g., Python, C++, etc.)?

What plotting programs do you know (e.g., TopCat, SuperMongo, IDL, etc.)?

What word processing programs do you know (e.g., LaTeX, Word, etc.)?

Please list the college level physics and astronomy courses that you have taken or are currently taking. Please use course names (e.g., “E&M”, “Quantum”), not course numbers (e.g., Phys 3390).