Syllabus for AST 2008, Fall Term 2007 - 2008
1. **Course Objectives**

AST 2008 is a general survey of the field of astronomy at a level intermediate between the 1000 and 3000 levels. Our goals are to acquire appreciation for the make-up and organization of the Universe, for our place within it, for the observations, experiments, and logical thinking that have led to present understanding, and for active questions at the interface between the known and the unknown.

2. **Learning how to learn**

We hear of athletes who reach levels of achievement far beyond their natural talents, and we hear of others with great ability who never progress to high levels. Sometimes an athlete matures over the years and performs better as his or her physical skills diminish. The importance of know-how in such persons is obvious. In a similar way, a student can develop mental skills that make understanding easier, longer lasting, and more useful, but first it is necessary to appreciate certain overview points. Notice that the goal is understanding, not memorization. If memorization were the goal, courses would not be needed - we could just take a list of facts and memorize them at home. A university is a place to learn how to think and learn how to learn. There are tricks and techniques for memorization, but they do not help in understanding. History has seen remarkable feats of memorization, such as remembering \( \pi \) to thousands of digits, but the memorizers are often below average in using information and thinking independently.

The next section will give some ideas on learning how to learn, but there are many more. For example, you could develop a mind-set where you put yourself in the place of the first person to come up with a concept. Imagine that you actually are that person and think through all the steps - reasons for being interested in the problem, having the basic ideas, testing them, refining them, etc. You may find it useful to think up little computational problems as you go along (yes, little ones - things you could do on a pocket calculator in a few keystrokes, or maybe without a calculator), and you may want to develop your own thoughts along these lines.

Another ingredient in good learning is realistic assessment of understanding. Briefly - don't be too easily satisfied. Try to see concepts from more than one point of view and check whether they all make sense. A paradox is a disagreement between explanations that should agree in their logical consequences. Paradoxes are initially upsetting because they force us into the discomfort of knowing that we don't understand. But paradoxes are our friends because they let us know when we go astray, hopefully before it's too late. So if two ways of seeing into a problem lead to a contradiction, ask questions - first of yourself and then in class.

One day a student in my 9th grade science class (yes, when I was in the 9th grade) was asked a question and had difficulty answering. After a few attempts, he said "well, I understand it but I can't explain it". The teacher responded with "let me tell you something from experience: if you can't explain it, you don't understand it!" That remark shocked the class because the student's excuse was a common thing to say. Over the years, I have grown to appreciate the teacher's wisdom by asking, whenever in similar difficulty, whether language is the problem. The answer always comes back: no, I know the necessary words and I know enough rules of English to put them together. What I need is to understand this thing better. Yes, every time. Teacher was right.

A helpful hint: It is recommended to print the day to day "computer pages" (on the web site under "Chapter 1", "Chapter 2", etc.) and use them for note taking. Not only will that help to organize your notes, but there will be less to write. The pages come out too small on some web browsers, such as Netscape and Mozilla, but Internet Explorer does a good job. Only a few of the images used in the lectures are on those pages, as most of them are subject to copyrights and cannot be freely re-distributed. In most cases, however, essentially equivalent illustrations are in the text book.

3. **Four Important Skills**

Years of experience show that the performances of many students in beginning level astronomy courses can be greatly enhanced if they improve four basic skills. These are

1. Interpretation of graphs
2. Visualization
3. A sense for rough sizes and locations (orders of magnitude)
4. Understanding of proportionality

All four skills can be improved by practice, but your practice may need some guidance. The skills
can help in other courses and throughout life. The following ideas should help:

3.1. Graphs

The first thing to do with a newly seen graph is to read the axis labels. A good habit is to do this immediately, even before you look at any plotted points or lines. Obviously there is no chance to understand a graph unless you know what is plotted. Next read the units on both axes and verify that they make sense (are consistent with the labels). Now look at the plot, but do something else as you look: Mentally "write" a concise sentence that describes the plot in simple language (imagine that your sentence is for someone who cannot see the graph). Finally, ask yourself "What is the point of the graph"?

3.2. Visualization

Ability to visualize objects and collections of objects in two and three dimensions is a skill that varies greatly from one person to another, but can be improved with practice and sincere effort. We will need only very simple visualizations in the course, but we will need those for sure. For such simple visualization, the main problem is unlikely to be lack of ability, but more often a lack of trying. We will have many pictures and diagrams that require visualization for proper understanding. If you are having trouble in this area, let me know. For a fun way to practice, listen to the old-time radio shows on the Sunday radio program "Theater of the Mind". There is no TV picture - you have to "see" the adventure by visualization.

3.3. Rough sizes, etc.

Much of the course is concerned with relative sizes and locations of astronomical objects. The important thing is what you take with you for ten, twenty, thirty, . . . years from now. Good memory of accurate numbers is unlikely and serves little purpose unless you will be a professional astronomer (and perhaps not even in that case). Therefore emphasis will be on overall perspective rather than memorization of numbers. You should acquire a sense for the sizes of galaxies, clusters of galaxies, and the scale of cosmology on the big end, and for the Solar System, distances between stars, and the internal parts of galaxies at the smaller end. As you read the assignments and in class, ask yourself: "Can I make a rough sketch of how things are arranged?", and then actually make such a sketch. Do not try to remember dimensions to several digits, but try not to be off by factors of ten or a hundred, and think about relative dimensions of related objects and separations.

3.4. Proportionality

We all have a sense for proportionality in everyday life. Unfortunately many students have trouble applying their good inner sense of proportionality when it comes to science. For example, suppose you are painting a room that has 800 square feet of wall area and you run out of paint when only 200 square feet have been painted. You used 1 gallon so far. How much paint should you buy to finish the job? I am sure that everyone can do this without being told the answer. Now change the problem so that it involves sizes and brightnesses of stars, perhaps related to a graph or an equation, and somehow the problem can look hard. This difficulty may arise from a lack of having learned the three ways to express proportionality and how those ways are connected. The three ways are:

1. In a graph: The graph of a proportional relationship is a straight line through the 0, 0 point (through the origin of the graph).
2. In an equation: The equation of a proportional relationship has the form \( A = KB \), where \( A \) and \( B \) are variables and \( K \) is a constant. A might represent paint in gallons and \( B \) might be wall area in square feet. Then \( K \) would be so many gallons per square foot.
3. In words: Example: \( A \) is proportional to \( B \) or "the amount of paint needed to cover a wall is proportional to the area of the wall".

Kind of simple, right? Would you believe that this notion causes study problems? The reason is that many students do not inter-relate the above ideas 1, 2, and 3. So draw some straight line graphs, write the corresponding equations, and express what you see in your own words. The benefits can be tremendous.

4. Compound Concepts

Suppose we are learning about the Doppler effect. (The Doppler effect is a good example because you may know something about it from another course, or at least have heard about it.) The Doppler effect may seem to be a single concept after we have a solid understanding, but actually several basic concepts have
to be put together to understand the Doppler effect, so it really is a *compound concept*. Some of those basic concepts in question form are:

- What is wavelength? What is frequency?
- What is a spectrum? Can I explain the idea of a spectrum in more than one way? What quantities are naturally involved in discussing or using spectra?
- Why are spectral lines useful, and in many circumstances indispensible, for measuring Doppler shifts?
- What is a spectral line? What does one look like? How wide are typical lines? What are bright lines? What are dark lines? What does "continuum" mean in this context?
- How are spectra made in astronomy?
- What is a comparison spectrum? How is one made? What is its purpose? How is that purpose achieved?
- Do I understand relative motion?
- What is meant by a Doppler shift? How is it measured?
- How does it depend on those things, if at all?
- What are some major uses of the Doppler effect?
- Etc., etc.

I will try to make clear as many of the separate concepts as can be squeezed into the lectures, but you are the person best qualified to put them together into unified (compound) concepts. You know how your mind works (each of us is different). One important way is to *ask questions of yourself* and try to answer them. Questions should naturally occur as you read the assignments - a good sign, showing that your mind is active. If very few or even no questions occur to you, then try to develop more inquisitive and critical ways to study. Such ways will help in your academic work far beyond this course.

5. Your Background

Although the course is essentially non-mathematical, you are expected to know high school mathematics such as working with fractions, exponents, and very simple equations.

6. Attendance

The past several years have seen a major drop in undergraduate attendance. This observation is based not only on my sections, but on communications from other Astronomy and Physics professors as well. Accordingly I have begun taking attendance on most days - a practice that did not seem necessary before about 1997. I am mentioning this up front because there is not much point to preaching the benefits of good attendance later, with those who need the sermon not being there. It may be that low attendance is connected with increased availability of class notes and course materials via the Internet, and resulting widespread confidence that satisfactory grades can be achieved without attending regularly. The reality is that there is an extremely strong correlation between attendance and grades in this course, and good attendance is a *requirement* for attaining an A or B+. There can be a good-attendance bonus for persons near the lower edge of the next higher grade.

7. Exam questions

It might seem that multiple choice exams cannot test understanding but they can and will do so in this course. Therefore if you focus on understanding and overall perspective, you should do well. If you focus on memorization - probably not.

8. Text Book

The book is "Astronomy Today, volume II - Stars and Galaxies" (4th, 5th, or 6th edition) by Chaisson and McMillan. There also is a combination book (volumes I and II combined) that will do, but it has much material that we will not use and is more expensive than volume II. Some of the illustrations in the classroom computer presentations are from the text book, although most are not. However many of the non-text illustrations are essentially equivalent to those in the text. The text illustrations are mainly quite good but you will experience more variety under this plan. I encourage you to find your own appropriate illustrations on the Internet, where you will find an enormous selection under most topics.

9. Classroom Participation

Be prepared for an interactive class. Please do not have negative feelings if your answer or comment is incorrect - we learn by jumping in and doing things,
right or wrong. I may sometimes give an explanation if I disagree with your response - that is not to emphasize how wrong it is, but to make clear that the disagreement does have a reason behind it - it is not just arbitrary. It is difficult to give proper credit for participation in a large class, but I shall try. If you have been participating and suspect that I might not remember your participation or know who you are, find some way to remind me - I want to raise your grade for such participation. There is no penalty for incorrect participation.

10. Exams

There will be three exams, which will be in multiple choice format and mainly not cumulative (the second and third exams involve only the material covered since the previous exam, with a few exceptions. The main exceptions are the basics of the early weeks, which you will need throughout the course). You are allowed one disaster day, which means that the lowest of your three grades will be dropped automatically. There is only one make-up exam and it comes at the end of the course. The dropped exam makes make-ups unnecessary in all but exceptional circumstances. Only students who missed more than one exam are eligible for a make-up and only a proper written excuse from an appropriate person (such as an M.D.) qualifies one for a make-up. Written excuses must be provided at the earliest practical time. There is no separate final exam.

Some students are good at guessing correct responses to multiple choice questions from subtle clues in wording. Experience shows that technique not to work in this class. As an experiment, I gave two exams to such a person (one not taking the course, but with pride in ability to identify correct answers). The results were somewhat below the guessing level, in agreement with my impression from exams administered to regular students. The moral: if you want to do well, you will need to understand the course material (really!), which will require good attendance and regular preparation.

Here are some other techniques that will not work:
1. Memorizing exam answers from previous years. (Because this year’s questions will be new - I do not use old questions again.)
2. Memorizing a list of facts. (Because very few, if any, of the questions test factual knowledge. If there are four possible responses to a question, there will be four explanations, only one of which follows from explanations in class. Usually the other three options will be very clearly wrong.)
3. Narrowing the choices by eliminating obviously silly responses that are intended only for amusement (there will not be any of those).

You will be pleased to know that:
4. You need not be concerned about subtle variations in responses. All will be clearly different and the wrong ones will definitely be wrong.
5. There will be no "all of the above" or "none of the above" answers, which I consider unfair, nor ones such as "both a and b", and so on. One answer is right and the others are wrong.

The questions and answers will be longer than you are accustomed to. The reason is that they involve explanations, not facts. Explanations need more words than do facts.

If you are not doing well at some point in the term, read this syllabus again. You may find clues into the nature of the problem. Experience shows that the students who do well mainly are those with a genuine interest in the subject matter. Those without such an interest can improve their performance by cultivating one as they go along. That should be easy - remember, it’s your Universe, and possibly the only one you will ever have.

11. Extra Help, Office Hours

Most students feel that they should see a professor only in desperate situations. However I have time to see you and you are welcome any time during office hours, which are Tuesday and Thursday from 3 to 5 PM. Occasionally something comes up and I cannot be here, but usually I will be around. If you want to come in at other times, make an appointment before or after class, or by telephone (392-2052, ext. 235). My office is 322 Bryant Space Science Bldg. My Email address is wilson@astro.ufl.edu. Please let me know that you are coming so that I will be sure to be in the office, even for regular office hours.

12. Aftermath

When you have completed the course, I hope you will look back on it as a learning experience not only in astronomy but also in the nature and methods of science. Science is our most effective way of understanding and coping with nature and the modern
technological world, and I try to present the material in a way that will help in other courses and in life beyond graduation. I especially value comments from students that are made 5 or more years after taking the course, when there has been time to see learning in perspective.

R. E. Wilson August 15, 2007