Astronomy 101: An Introduction to the Universe

There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact. - Mark Twain

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SSB 105
MWF 11:15-12:05

Instructor:	Elizabeth (Betsey) Adams
	SSB 518
	eaa39@cornell.edu
Office Hours:	TR 14:00-16:00
Course Website:	www.astro.cornell.edu/~betsey/a101
Textbook:	*The Cosmic Perspective*; Bennett, Donahue, Schneider & Voit
Grading:	Letter, 3 credit hours

I. Rationale:

The quote at the start of syllabus comes from when Mark Twain applies a naive extrapolation of short-term changes in the length of the Mississippi River to much longer time scales to derive nonsensical answers. In this class we will discuss when and how scientists can make accurate inferences and extrapolations from data. We will do this specifically in the context of delving into the story of astronomy, building up the picture of our Universe outward from Earth to the Solar System to the Galaxy to the cosmology of the Universe. We will cover five broad subject areas in the course:

- Motions in the Sky
- Stars: Birth, Life, & Death
- Galaxies & Black Holes
- Cosmology: From the Big Bang to the Present Day
- Life in the Universe

This course is fulfills a general education science requirement and does not require any prerequisites. However, familiarity with high school math and science will be assumed.

II. Course Aims and Objectives:

Aims

As this a general education science course, you will develop the following skills during this class:

- **Critical Thinking and Problem Solving Skills:** You will develop systematic skills for approaching problems. This includes being able to take a problem, break it down into component parts, recognize what knowledge you have and don't have, find the missing knowledge, and apply it to solve the problem.
- **Mathematical Reasoning:** You will develop the ability to understand relationships

between quantities and the knowledge to apply those relationships to derive solutions to problems. We will also focus on how to estimate quantities.

Specific Learning Objectives:
By the end of this course, you will, for the following topic areas, be able to:

Motions in the Sky
- Apply Kepler's laws in our Solar System and other planetary systems
- Explain the origin of seasons on Earth

Stars: Birth, Life & Death
- Use a Hertzsprung-Russell diagram to describe a given stellar population
- Explain the origin of elements heavier than helium
- Describe the death of stars for a range of masses

Galaxies & Black Holes
- Describe the extra-galactic distance ladder and articulate how each rung depends on the previous step
- Understand and correct common misconceptions of black holes

Cosmology: From the Big Bang to the Present Day
- Describe evidence for the Big Bang
- Describe dark matter and dark energy and articulate the differences between the two

Life in the Universe:
- List necessary ingredients for life
- Use Drake's equation to estimate probability of life
- Determine if a planet is in the habitable zone

III. Format and Procedures:
This course meets 3 times a week for 50 minutes. My goal is to focus on creating a learning environment for you and reducing the amount of lecture. This requires you to come to class prepared, having done the required readings. Most often, class will consist of 2 mini lectures, each approximately 15 minutes. The rest of the time will involve demonstrations of some combination of the following learning activities:

Think-Pair-Share Questions: These are multiple choice questions aimed at assessing your understanding of lecture material. You will think on the question on your own and answer it. You will then engage with your partner and convince them of your answer. You then answer the question again. The answers to these questions are not graded – they are a way for me to test understanding and ensure that I am effectively covering material.

Tutorials: Tutorials are worksheets designed to take you through the steps of understanding a concept. You are expected to work in small groups on the tutorials and

engage with your group members. The tutorials may be collected for participation but will not be graded.

Reflective Writing: In most classes, I will ask you to write a short response (5 minutes) to a prompt. I may ask you to explain something in your own words or to describe to me what you still don't understand. These writings will be collected for attendance but will not be graded. I will review the responses to assess the effectiveness of that day's class.

IV. My Assumptions

My goal is to create a course that is focused on you, the learner and to create opportunities for learning to happen. I will attempt to minimize my time lecturing, as learning happens when you are engaged with the material, not when I am presenting it. I believe one of the best ways to encourage learning is through peer interaction so you will be continuously asked to work with partners or in groups.

I have the following expectations of myself and you:

Of You:

- Attend class and **participate**
- **Prepare** for class, e.g. complete readings and vocab questions
- **Dedicate** time. This is a 3 credit course, which implies you are expected to spend 6-9 hours outside of class time on this course.
- **Engage** in your own learning. In order for this class to be a productive experience for you, you need to be an active participant in your own learning.

Of Me:

- **Transparency**. Grading and assignments are as outlined in this syllabus. Lecture will cover material relevant to assessments. I will be open in my rationale for assignments and activities. There should be no surprises in this course.
- **Support** your learning. My job is to create an environment in which you can learn.
- **Respond** to feedback. I will offer evaluations several times during the semester in order to adapt the course as necessary to meet your learning needs.

V. Course Requirements: Whatever tasks and assignments you include in your course should be aligned with the specified learning outcomes (final learning state, skills, knowledge, attitudes and values the students leave the course with) you have defined and specified earlier.

1. Class Attendance and Participation

As every class will involve in-class learning activities, it is of paramount importance that you attend every class and participate. Attendance will be taken every day; you are allowed to miss six days – use them wisely. (In extenuating circumstances, contact me. But realize that you are given two out of fourteen weeks to be absent at your discretion.) In-class activities will be occasionally collected for the participation grade; I will collect 12 activities and you need to have 10 for full credit. The activities will be checked for a good-faith effort but will not be checked for accuracy. If you are creating a disruption or actively stopping the engagement and participation of other students, your participation grade will be docked. In each instance, a warning will be issued and if the disruptive

behavior continues, you will lose 5% of your participation grade for the semester.

2. Reading Questions
The book for this course is *The Cosmic Perspective*. You are expected to complete the assigned reading ahead of class to allow class time to be devoted to engaging with the material. Part of your grade will come from answering reading questions before class. These questions will be designed to test your understanding of the reading rather than fact memorization – you will need to pay attention to the reading. The questions will be completed online a minimum of half-an-hour before class. This provides me with enough time to review your answers and adjust lecture to focus on areas of difficulty.

3. Assignments
There will be five major assignments throughout the semester, one for each unit. These assignments will consist of two parts. The first part will consist of a series of short questions, similar to questions from in-class activities. You are encouraged to work on this part of the assignment with classmates but will turn in your own copy. Your copy should include the names of all the people you worked with. The second part of the assignment is an open-ended question to be completed in assigned groups. The open-ended question will ask you to apply knowledge from that unit (and previous units) in a situation of your own devising. Tentatively, the five open-ended assignments are:

- Design Your Own Solar System, Part I: Dynamics
  Pick a star and place planets around it. What are the periods of the planets? From the 3rd planet out, describe the apparent motions of the other planets in the night sky. Do any other planets show phases? If so, draw them. You will solidify your knowledge of Kepler's laws and apparent motions in the night sky in this activity.
- Make Your Own HR Diagram
- We've discussed how the HR diagram is a plot of two variables but also contains information about the stage of a star's life. Make a similar diagram for something of your choice. Label your axes and the stages of life. Why did you choose the axes you did? Now create a synthesis diagram for a population of your choice. How can we retrieve information about the population from your diagram? Note: Your assignment will contain an example and you should make a choice that differs significantly from the example. This activity will help you explore how the HR diagram also contains time evolution information and also contains information about a population of objects.
- Your Favorite Extra-galactic Object
- Pick a favorite extra-galactic object. Why is it your favorite? How do we know the distance to it? What would be different about this object if we were wrong about the distance and it were twice as close? Twice as far? In this activity you will do some more digging into an object of your choice, plus you will focus on how dependent our understanding of the Universe is on knowing accurate distances.
- Pick Your Own Scale
- The Universe is vast and it's hard to comprehend sizes, distances, and scales. It helps if we put things in familiar terms. We've talked in this course about how we can scale things down to help us understand. Pick your own scale(s) for this activity

and describe the Solar System, Galaxy, Local Group and Virgo Cluster. (Hint: You will probably want to set a new scale for each category above.) We can also scale in time. Astronomical time scales are long and it can be difficult to comprehend them. Take Figures XX,YY,ZZ from your text and create time scales of your own devising for the history of the Universe, stellar lifetimes for different masses, and different stages of evolution for a solar mass star. This activity will help you get a sense of the vast times and distances we have talked about in this course as you scale things down to a scale that is comprehendable.

- Design Your Own Solar System, Part II: Life

Return to your planetary system from the first assignment. Where in the system are you most likely to find life? Why? How might things be similar and different to life on Earth (temperature, seasons, year, etc.)? In this assignment you will explore our current understanding about how life may exist and form in the Universe.

4. Group Assessments

With each of the five assignments and the final project, you will hand in an assessment for each member of your group. This ensures that each member of the group is contributing properly.

5. Final Project

As a final project you will be asked to pick a telescope and argue for why it should receive funding. This project will consist of a 7-10 page report and a poster presented at a scheduled poster session (during the final exam time). For this project you will be expected to provide information both on the telescope (location, cost, engineering, etc.) and on the science the telescope will accomplish. You will choose three science areas in which the telescope will make contributions, explaining them using what you learned over the semester. This project will allow you to focus on the topics you found most interesting in the course.

V. Grading Procedures:

The grade for this course will be assigned in the following manner:

Attendance	5%
Reading Questions	5%

Participation	10%
Assignments	30%
Final Project	40%
Group Assessment	10%

Letter Grades will be assigned in the following manner:

A+	100%
A	93-99%
A-	90-92%
B+	88-89%
B	82-87%
B-	80-81%
C+	78-79%
C	72-77%
C-	70-71%
D+	68-69%
D	60-67%
F	<60%

VI. Academic Integrity

Each student in this course is expected to abide by the Cornell University Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work or the group's work. Collaboration is encouraged for the non-group portion of the assignments but the work handed in should still be your own work.

You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students.
However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an e mail, an e mail attachment file, a diskette, or a hard copy.

Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Code can also be extended to include failure of the course and University disciplinary action.

During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

VII. Accommodations for students with disabilities

In compliance with the Cornell University policy and equal access laws, I am available to discuss appropriate academic accommodations that may be required for student with

disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with Student Disability Services to verify their eligibility for appropriate accommodations.

VIII. Tentative Course Schedule

Week	Topics
Week 1	Introduction, Observed Sky
Week 2	Kepler's Laws & Motion
Week 3	Light: Flux, luminosity, spectroscopy, blackbody radiation
Week 4	Main Sequence & the HR diagram
Week 5	Stellar Birth & Death
Week 6	Production of Elements
Week 7	Applying the HR diagram
Week 8	The Distance Ladder
Week 9	Galaxies & Black Holes
Week 10	Galaxy Relations
Week 11	The Big Bang & Dark Universe
Week 12	History of the Universe
Week 13	Habitable Zone & Drake's Eqn
Week 14	TBD