ASTR 226: Cosmology

Welcome!

Instructor: Dr. Katie Lester, klester@mtholyoke.edu, 213 Kendade Hall
Please feel free to call me Katie, but I also understand if you are more comfortable using a formal title such as Professor Lester, Professor Katie, Dr. Katie... During the week, I will try to answer any emails within 24 hours. Over the weekend, I may not get back to you as quickly. If you do not hear back from me in two days M-F, please email me again.

Office Hours: I will hold office hours each week on Mondays 2–4pm and Thursdays 10am–12pm, so stop by any time you have questions or want to chat. You're also welcome to email me anytime with questions or to arrange a different meeting time that fits both our schedules. You can also schedule meetings on Pathways.

TA: Azmé Tariq (tariq24a@mtholyoke.edu) is the TA for this class. Azmé is available to help you with the course material or homework questions during her own help hours (Thursdays 3-5pm in Kendade 229), so feel free to contact me or Azmé if you need help!

Overview

Course Description: What is the universe made of? How did it begin? How has it evolved over the 13 billion years since its origin? And how will it end? These are the questions addressed by cosmology, the study of the universe as a whole. Research in cosmology involves astronomy, but also gravitational physics, particle physics, and challenging questions about the interpretation of phenomena we can't see directly — such as the possible existence of something before the Big Bang. We will study in detail:

- Techniques to measure the size, shape, and evolution of the universe.
- Cosmological models and the relationship between models and observable parameters.
- Topics in current astronomy that bear upon cosmological problems: background electromagnetic radiation, nucleosynthesis, dating methods, determinations of the Hubble constant, and tests of gravitational theories.

Course Website: Moodle will contain lecture slides, homework assignments, announcements, grade book, and all other course materials.

Textbook: There is no required textbook, but we will broadly follow Big Ideas in Cosmology.

Prerequisites: ASTR-100 or ASTR-102; one semester of physics; and one semester of calculus at high school or college level.

Grading

Homework (50%)
There will be homework due every 2 weeks that will include qualitative and quantitative questions. You're encouraged to work on assignments with your classmates, but each of you must write your homework

in your own words! Make sure to show all of your work for math problems – information that was given, values you're trying to find, equations you could use, steps you took to solve the problem, and checking that your answer makes sense. Please hand write (or digitally write) your homework and turn in a physical (or printed) copy by the start of class on the due date.

Each homework problem will be graded on a 10-point scale:

10	Perfect	You made no errors and wrote everything neatly & clearly!
9	Excellent	You've mastered the problem, but there are some minor mistakes or missing explanations.
8	Good	You've made a great attempt at solving the problem, but there is one major error or many small errors.
7	Poor	You've somehow missed the point of the problem or haven't addressed it adequately.
0		No attempt at solving the problem.

Every assignment has a due date and I expect you to strive to submit each assignment by this date (accounting for any accommodations you have). This ensures I have an opportunity to give you feedback before we review the homework in class. Missing one homework often leads to missing another one, and getting behind is overwhelming and can derail your ability to make progress towards our learning goals. I want you to succeed so if you anticipate a problem meeting a homework due date, email me to propose an extension and we will come to an agreement together. I am always willing to be flexible if you contact me in advance of a due date. Homework turned in 7 or more days past the deadline (without an extension) will be graded for 50% credit.

Once each homework is graded and returned, you have the opportunity to submit a redo to move up one grade on the 10-point scale. These redo's have two required parts: (1) redone homework problem(s) that you got wrong, and (2) a short reflection on what went wrong the first time and how you could avoid this mistake in the future. These reflections will help you manage your time better and avoid making the same errors on future homework in addition to helping you think through which concepts you need to review in more detail. These redo's are due anytime before the first day of final exams.

Participation (20%)
I hope you come to class and actively participate in this course so you can best engage in learning. We will often do example problems and activities in class, which you're encouraged to work on with your classmates. These activities are graded only on completeness, but will help you learn the material and practice what will be on the homework. Your participation is not only an important part of your learning, it will also contribute to the learning of your peers. As members of our learning community, each of us has a responsibility to create an environment in which we can all learn from each other.

Exams (30%)
We will have 3 in-class exams throughout the semester, each worth 10% of your grade. (See the schedule for details). None of the exams will be cumulative, although many topics will overlap between the exams. These will include both short answer qualitative and math problems, and you will be given a choice of which questions you want to answer. (For example, completing 4 out of 5 questions.) Exams will be closed book, but I will give you an equation / constants sheet for reference. Exam questions will be graded on the same 10-point scale as the homeworks.

Final grades:

A $\geq$ 94	B+ = 87-89	C+ = 77-79	D+ = 67-69	F $\leq$ 59
A – = 90-93	B = 83-86	C = 73-76	D = 63-66	
	B – = 80-82	C – = 70-72	D – = 60-63	

Learning Goals:

With this course, we present the study of the universe at the largest scales as an investigative, evidence-based, and interdisciplinary science. We strive for students to learn to employ quantitative concepts and mathematical methods, analytical thinking, and demonstration of the sensibilities, understandings, and perspectives of a person educated in a liberal arts tradition (particularly as these sensibilities relate to the natural environment). We aspire to prepare students to make informed decisions as stewards of their environment in their roles as voters, consumers, and contributing members of society.

Each assignment you complete in this course will contribute to your growth towards meeting specific learning goals:

1. Understand fundamental concepts in astronomy such as gravity, the nature of light, the origin of the universe, and physical characteristics of matter.
2. Demonstrate skills for quantitative analyses, including the ability to form a hypothesis, graphically represent and interpret data, estimate error and understand sampling bias.
3. Show a working knowledge of a broad array of physical phenomena that are based upon fundamental concepts.
4. Gain familiarity with instrumentation, computational methods and software resources utilized by professional astronomers.
5. Demonstrate use of critical thinking skills in well-organized, logical and scientifically sound oral and written scientific reports.

What you can expect from me:

- I will provide you with a clear, organized course that is designed to ensure you meet our learning goals in a meaningful manner.
- I will provide a variety of activities & assignments to ensure your learning needs are met.
- I will provide a supportive and safe environment for you to share and discuss ideas with your peers.
- I will treat you with dignity and respect and be flexible to support your individual needs.
- I will reach out to you when I sense that you need support.

What I will expect from you:

- You will strive to be an active participant in this course by coming to class, taking notes, and participating in peer discussion or class activities.
- You will focus on understanding the concepts and performing the skills of this course, aiming for your own personal best.
- You will strive to meet due dates, but will contact me if you have a concern about completing an upcoming assignment.
- You will uphold academic integrity by submitting only work that you understand and completed for

yourself.

- You will be thoughtful in your interactions with peers, while taking extra care to respect diverse perspectives. You will support your classmates as you share this learning space and treat them with dignity and respect.
- You will give yourself grace. You will challenge yourself to keep an open mind and recognize that mistakes are a vital part of the learning process.

Class Guidelines

Accommodations
Please let me know if you need any accommodations from the Disability Services office (Mary Lyon Hall 3rd Floor or by email). I would like to meet with you and discuss your approved accommodations and how we can apply them to this class. (For more information on who might be eligible for accommodations and the application process please see the Disability Services website.)

Academic Integrity
I encourage you to work together on homework, since science is often very collaborative. You can help each other with questions and try to figure them out together, but each person must write up their work individually. You are expected to follow MHC's academic integrity policy, and any work that does not will be given a zero and reported to the Academic Honor Board. Each student is required to write up and submit their own work. Using artificial intelligence on assignments is prohibited; students should not have another person/entity do the writing of any portion of an assignment for them, which includes AI tools like ChatGPT.

Mount Holyoke College is a community of students, faculty, staff, and administrators committed to free inquiry and the pursuit of knowledge in the tradition of the liberal arts. The decision to join this academic community requires acceptance of special rights and responsibilities that are essential for its effective functioning and the realization of its mission. All members of the community share the responsibility to uphold the highest standards of academic integrity. I expect all your work to abide by the MHC Honor Code: "I will honor myself, my fellow students, and Mount Holyoke College by acting responsibly, honestly, and respectfully in both my words and deeds." Any work that does not will be reported to the Academic Honor Board.

Tips for success
To help reduce that stress and improve your own likelihood of getting the best grades possible, allow yourself the time and space you need to do your best work. Do not procrastinate and if you get stuck on an assignment, please reach out to me or the TA. I welcome your questions and I am happy to help you think through your ideas so you can successfully complete an assignment. Sometimes just a quick conversation or email exchange is all you need resolve a problem. Struggle is a natural part of learning, but if you're feeling frustrated that means it is time to reach out for some assistance.

Some of the homework questions will ask you to give an answer *and* to explain your reasoning, which shows your understanding of the course material and critical thinking skills. You need both components to receive full credit for the question, so try to explain your reasoning in detail. Imagine you are explaining the answer to your classmates – walk through each step in your thought process and give evidence to support your ideas.

ASTR 226 Schedule Fall 2024				
Week	Date	Topic	Reading	Assignment
1				
	Sep 05	Introduction	Ch. 0	
2	Sep 10	Light, energy, spectra	Ch. 2	
	Sep 12	Telescopes, images	Ch. 3	
3	Sep 17	Review of stars	Ch. 1, 5	HW1 due
	Sep 19	Distance ladder (parallax, standard ruler)	Ch. 6	
4	Sep 24	Distance ladder (Cepheids, SN, MS fitting)	Ch. 6	
	Sep 26	Review of galaxies	Ch. 1, 5	
5	Oct 01	Distance ladder (Hubble's law), redshift	Ch. 6	HW2 due
	Oct 03	Gravity, dark matter	Ch. 7, 8	
6	Oct 08	Review		
	Oct 10	Exam 1		
7	Oct 15	No class		
	Oct 17	Hubble's law, expansion	Ch. 13	
8	Oct 22	Expansion, Big Bang, CMB	Ch. 15	HW3 due
	Oct 24	History of the universe, inflation	Ch. 16	
9	Oct 29	Growth of structure, galaxy formation	Ch. 14	
	Oct 31	Dark energy	Ch. 17	
10	Nov 05	General relativity	Ch. 10	HW4 due
	Nov 07	Buffer for mountain day		
11	Nov 12	Review		
	Nov 14	Exam 2		
12	Nov 19	General relativity	Ch. 10	
	Nov 21	Friedmann eq	Ch. 17	
13	Nov 26	Friedmann eq	Ch. 17	
	Nov 28	No class		
14	Dec 03	Curvature, critical density	Ch. 17	HW5 due
	Dec 05	Fate of the universe	Ch. 17	
15	Dec 10	Review		
16	Dec 13 - 16	Exam 3 (self scheduled)		