

AS 109 – Cosmology (Spring 2021)

Last updated on 01/26/2021

Professor Tereasa Brainerd (she/her/hers)

phone: 617–353–6646

Email: brainerd@bu.edu

Office Hours: Tues. & Weds. 5:00pm – 6:30pm and by appointment (**remote only**)

Adam Samuels (he/him/his)

Email: asamuels@bu.edu

Office Hours: Mon. 11:30am – 12:30pm and Tues. 1:45pm – 3:45pm (**remote only**)

Aislynn Wallach (they/them/theirs)

Email: aewall@bu.edu

Office Hours: Thurs. 2:00pm – 4:00pm and Fri. 2:00pm – 3:00pm (**remote only**)

Course Overview

Cosmology is the study of the origin, structure, and evolution of the universe as a whole. We will be concerned with some of the most fundamental questions that humans can formulate such as “What is the universe and what is our role in it?”, “Did the universe have a specific beginning or has it always existed?”, and “Will the universe as we know it exist forever?”.

Cosmology focuses on the “big picture” and is not so concerned with specific objects in the universe (e.g., individual planets, stars, or galaxies). However, we will need to understand the basic nature of many of these objects in order to understand the full modern picture of the origin and evolution of the universe. To do this we will apply the laws of physics as we know them on earth to objects that we observe in the universe. The level of physics used in this class will be somewhat qualitative, but it will encompass many of the basic concepts of modern physics including atomic and nuclear physics, elementary particle physics, the nature of the spacetime continuum, and the theories of special and general relativity.

Although we will be following the textbook fairly closely and we will cover material from many of the chapters, there is far too much information in the book to be covered in detail over the course of only one semester. Students will be expected to read the material in the text that is appropriate to the lectures and to use the index in the book to look up specific topics when necessary. We will also cover some material that is not included in the textbook, and students will be responsible for knowing this material.

Physics & Mathematics

Astronomers use the laws of physics to interpret observations of the universe. Physics is a mathematical description of nature and, thus, at times it will be crucial to use mathematics in this course. The primary focus of the course will be on understanding the concepts; however, many simple mathematical formulae will be necessary in order to make certain points clear. The mathematics will not exceed the level of high school algebra and all formulae will be

explained in words. Professor Alan Marscher has written a helpful mathematical techniques primer that students may wish to use for reviewing the relevant types of mathematics that we will be using. A PDF version of this document is posted in the course Content of Blackboard (see the folder named “Mathematics Review Material”).

Course Website

All course materials will be posted on Blackboard (<http://learn.bu.edu>).

Required Textbook

AS109 will be using *The Cosmic Perspective (9th Edition)* **with Modified Mastering Astronomy** by Bennett, Donahue, Schneider, and Voit. It is extremely important that you purchase the correct version of the textbook, including access to Modified Mastering Astronomy. AS109 will be using Modified Mastering Astronomy for various aspects of the course, and if you do not register for Modified Mastering Astronomy you will be unable to complete the course. The ISBN for the Modified Mastering 18 month access code **with etext** is: **9780135208113**.

Learn from Anywhere

AS109 will be adopting the LfA model for the semester. When possible, lectures will be live “in person” in room CAS502, with synchronous remote participation available through Zoom. Lectures will take place on Tuesdays and Thursdays from 12:30pm to 1:45pm (US Eastern time). All discussion sections and office hours will be held as live remote Zoom sessions. All lectures will be recorded via Zoom and will be posted on learn.bu.edu for those students wishing to engage in remote, asynchronous learning. **Discussion sections and office hours will not be recorded.** Note: all Zoom recordings will be processed through Kaltura Media so that they cannot be downloaded. Only Professor Brainerd and students who are registered for AS109 will have access to the recordings. Information on Zoom meeting IDs and passwords will be posted on learn.bu.edu. **Do not share the Zoom meeting IDs or passwords with anyone who is not registered as a student in AS109.** Students who do not wish to have their images and/or voices recorded may opt out in various ways. Students attending in person who wish to opt out of video recording should sit out of view of the room camera when it is in use. Students attending in person who wish to ask a question, but who also wish to opt out of having their voices recorded, can use the Zoom chat. Students attending remotely who wish to opt out of video recording should keep their cameras off, and they may also choose to use an alternative, non-identifying Zoom name that has been shared privately with Professor Brainerd in advance of the Zoom session. Students attending remotely who wish to ask a question, but who also wish to opt out of having their voices recorded, can use the Zoom chat. Students who are attending remotely can also call in to the Zoom session with caller ID disabled.

SARS-CoV-2/COVID-19 Safety Protocols

All students must adhere to BU’s strict guidance on preventing the transmission of SARS-CoV-2, the novel coronavirus that causes the disease known as COVID-19. Students attending class in person must wear a face covering that covers their mouths and noses at all times, must maintain physical distancing of at least 6 feet at all times, and are responsible for sanitizing their chairs and desks both prior to the start of class and after class has ended. BU will be

providing sanitizing wipes for this purpose. **Eating and drinking in CAS502 and in the hallway outside CAS502 is absolutely prohibited.** Students who fail to adhere to BU's strict guidance on COVID-19 safety protocols will be reported to the office of the Dean of Students. For guidance on BU's COVID-19 safety protocols, students should refer to <https://www.bu.edu/back2bu/>.

BU Hub Learning Outcomes

AS109 satisfies the requirements for the BU Hub learning outcomes for Scientific Inquiry I, Quantitative Reasoning I, and Critical Thinking (part of the Intellectual Toolkit).

Scientific Inquiry I: In AS109 students will learn some major concepts of physical science and how these are applied to natural phenomena that humans observe in the universe. The main intellectual content of the course concentrates on how scientists characterize and explain the universe. This involves (1) methods of measuring distances, masses, velocities, temperatures, and other physical properties of cosmic objects; (2) a variety of physical principles, such as particles and fields, behavior of gases conservation laws, relativity, and orbital motion; and (3) physical processes such as the formation of galaxies, stars, and planets, evolution of stars, and expansion of the universe.

Quantitative Reasoning I: AS109 will use basic mathematical equations, algebra, and graphs to apply physical concepts to cosmic phenomena, and to infer physical properties from data. The discussion of physical principles will involve the presentation and use of formulae, including the use of algebra to solve the equations in order to derive values of important physical quantities. Graphs will be used extensively in order to indicate trends of how one physical quantity depends on another (e.g., how the velocities at which galaxies recede from us depend on their distances).

Critical Thinking: The first section of the course will cover the scientific method. This will include a discussion of the differences between inductive and deductive reasoning, and how both are used to advance our scientific knowledge. The main emphasis will be on prediction and testing of hypotheses. Emphasis will also be placed on the incomplete nature of scientific knowledge, which is subject to future tests and possible falsification.

Instructional Format, Course Pedagogy and Approach to Learning

The normal class schedule will include two lectures per week and weekly discussion sections. Students are expected to attend, and participate in, all lectures and discussion sections unless their absence is excused (for e.g., medical reasons or observance of religious holidays, as outlined in BU's Policy on Religious Observance). Both the lectures and the discussion sections will incorporate the Socratic "question and answer" style of instruction, where students are actively challenged to actively engage with the material. **All students are strongly encouraged to be active participants in class.** The more class participation, the more fun and engaging the class will be!

Academic Conduct

Students are expected to know and understand the Academic Conduct Code. A copy of the Academic Conduct Code is posted at <http://www.bu.edu/academics/resources/academic-conduct-code/>. Cases of suspected academic misconduct (e.g., plagiarism or cheating on examinations or quizzes) will be referred to the CAS Dean's Office. Unauthorized downloading, uploading, sharing, and/or duplicating course materials including, but not limited to, assignments, exams, quizzes, slides, videos, and any other material created and/or provided by the instructor without the instructor's express permission is a violation of the Academic Conduct Code.

Grading

Homework Assignments (approximately weekly, lowest 2 scores dropped) – 20%
Discussion Section Quizzes (lowest 2 scores dropped) – 15%
Kaltura Video Quizzes – 5%
Midterm Exams (two in total, 15% each) – 30%
Final Exam – 30%

Homework

Homework assignments will be due approximately once a week and will be completed via Modified Mastering Astronomy. All homework assignments must be completed by the due date and time specified on the assignment. **Late homework will not be accepted.** Instead, each student's two lowest homework scores (including any zeros due to missed homework) will be automatically dropped.

Kaltura Video Quizzes

In Spring 2021, BU will not be holding its usual Spring Break week. Without a Spring Break, students may find it more strenuous than usual to get through the semester. To help break up the semester and give students some flexible free time (in addition to the two planned Wellness Days), two of the regularly-scheduled AS109 lectures will be replaced by short, pre-recorded videos with quizzes embedded within them. Students will have access to the video quizzes via Blackboard for a full week at a time, so they can watch the videos and complete the quizzes at times of their own choosing.

Examinations & Quizzes

Examinations and quizzes are an important component of students' grades in AS109. Critical to a fair assessment of each student's understanding of the material is that students complete the examinations and quizzes individually, not in collaboration with each other. **Students collaborating with each other to answer the questions is a clear violation of the Academic Conduct Code.** Simply put, it is cheating. Students caught cheating on quizzes or exams will be reported to the CAS Dean's office for disciplinary action.

Lecture Outline

Overview

- cosmology and the physical universe
- the scientific method (Ch. 3.4)
- the cosmological principle (Ch. 20.3)
- a modern view of the universe (Ch. 1)
- the scale of the universe (Ch. 1.1)
- spaceship earth (Ch. 1.3)

Historical Cosmology

- motions of the planets through the sky (Ch. 2.4)
- ancient observatories (Ch. 3.1)
- Aristotelian physics
- Ptolemy's model of the solar system (Ch. 3.2)
- Copernicus, Tycho & Galileo (Ch. 3.3)

The Cosmologist's Tool Box

- motion, energy and gravity (Ch. 4)
- light (Ch. 5)

Relativity

- space and time (Ch. S2)
- spacetime and gravity (Ch. S3)
- black holes
- gravitational lenses

Galaxies

- the universe of galaxies (Ch. 20)
- galaxy evolution (Ch. 21)

Dark Matter and the Fate of the Universe (Ch. 23)

The Birth of the Universe (Ch. 22)

Letter Grades

Letter grades will be assigned at the end of the course and will not be given on examinations. The final class grading curve will be determined after all elements of the grading scheme have been tabulated (quizzes, homework, midterm and final examinations) and your final letter grade will be determined based upon your ranking in the class overall. Historically, the final average letter grade in AS109 has been approximately a B- (i.e., 2.7 honor points). Shown below is a sample curve for a class with a total of 80 students, which is approximately the number of students in this year's class. This curve below is based on a combination of the actual class curves from six previous offerings of AS109. Note that this is not the curve which will necessarily be used for this class; rather it is an example of the **typical** letter grades that would be earned by a student's particular ranking in the class over all.

A : 1st to 8th
A- : 9th to 17th
B+ : 18th to 31st
B : 32nd to 42nd
B- : 43rd to 53rd
C+ : 54th to 60th
C : 61st to 66th
C- : 67th to 74th
D : 75th to 79th
F : 80th