

## Astronomy 376C: Cosmology

UNIQUE NUMBER: 48360

Fall 2023

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**CLASS MEETS:** MWF 11AM to 12 PM (PMA 15.216B)

**Instructor:** Prof. Julian Muñoz

Pronouns: He/him/his

Office: PMA 16.332                      Office hours: M 1-2 PM and by appointment

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**TA:** Wichahpi King

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## Course Description

AST 376C is an introduction to Cosmology at a level suitable for Astronomy or Physics Majors. Cosmology is the study of our universe as a whole, focusing on its content and evolution. This course covers the basics of the physics and astronomy inherent to cosmology, from the formation of the first elements a few minutes after the big bang to the large-scale structure of the universe around us, and key epochs in between. During this course, you will:

- gain mathematical understanding of equations explaining the evolution of the Universe
- develop physical intuition about the universe, its contents, and its evolution over cosmic time
- learn about dark matter, dark energy, the intersection of astronomy and particle physics, and the expanding Universe, among other topics.

Cosmology is an active research discipline. Some of the items covered (e.g., dark matter and dark energy) are still a mystery. Yet, by the end of this course, you will understand why we think that the matter and energy in the Universe are dominated by this “dark sector”. We will cover some other unresolved questions such as the emergence of the cosmic structure and reionization. The class is intended for Physics and Astronomy majors, as well as those with a strong technical background in Physics and Astronomy. The course will assume a good working knowledge of calculus and Newtonian dynamics, as well as familiarity with differential equations. If you have concerns about the level of physics or math in the course, please contact me. All necessary astronomical terms and concepts will be introduced. Astronomy 376 (Topic: Cosmology) and 376C may not both be counted.

## PRE-REQUISITES FOR THE COURSE

Upper-division standing, and one of the following: Physics 301 and 303L; 301 and 316; 303K and 303L; or 303K and 316.

## FLAG COURSES

This course carries the Quantitative Reasoning flag. Quantitative Reasoning courses are designed to equip you with skills that are necessary for understanding the types of quantitative arguments you will regularly encounter in your adult and professional life. You should therefore expect a substantial portion of your grade to come from your use of quantitative skills to analyze real-world problems.

## How Will You Learn?

### STATEMENT OF LEARNING SUCCESS

I am confident every person in the class can learn the material and earn a good grade, provided you engage with the material deeply. My main recommendation is to be honest to yourself about how well you understand concepts and equations. It's OK to be confused, and it's OK to ask questions!

I understand we all learn differently, and encounter difficulties at times. If there are aspects of this course that prevent you from learning or exclude you, please let me know as soon as possible. I also encourage you to reach out to the student resources available through UT and I am happy to connect you with a person or Center if you would like.

### TEACHING MODALITY INFORMATION

Classes will be in person at PMA 15.216B. We will meet 3 times a week (MWF 11 AM to noon), and mix lectures with in-class activities and quizzes.

### COMMUNICATION

The course Canvas site can be found at [utexas.instructure.com](http://utexas.instructure.com). **Please make sure you can access emails through Canvas.** You are responsible for ensuring that the primary email address you have recorded with the university is the one you will check for course communications because that is the email address that Canvas uses.

### DISABILITY & ACCESS (D&A)

The university is committed to creating an accessible and inclusive learning environment consistent with university policy and federal and state law. Please let me know if you experience any barriers to learning so I can work with you to ensure you have equal opportunity to participate fully in this course. If you are a student with a disability, or think you may have a disability, and need accommodations please contact Disability & Access (D&A). Please refer to the D&A website for more information: <http://diversity.utexas.edu/disability/>. If you are already registered with D&A, please deliver your Accommodation Letter to me as early as possible in the semester so we can discuss your approved accommodations and needs in this course.

It is my intent that students from all backgrounds be well served by this course, that students' learning needs be addressed, and that the perspectives that students bring to this class can be comfortably expressed and be viewed as a resource, strength and benefit to all students. Mental health is important, and you're not alone. Please reach out to me or the different resources on campus (UT CMHC and UT BCAL) at any time with any concerns. For more information on CMHC, visit [cmhc.utexas.edu](http://cmhc.utexas.edu) or call 512-471-3515 and for BCAL at [safety.utexas.edu/behavior-concerns-advice-line](http://safety.utexas.edu/behavior-concerns-advice-line) or by calling 512-232-5050.

## Course Requirements and Grading

### REQUIRED MATERIALS

The textbook we will use is **Introduction to Cosmology (Second Edition)**, B. Ryden (Cambridge University Press, 2017). Please be sure to get the second edition, not the first edition. The book is available at the Co-op and at amazon.com (to purchase or rent), among other places. For an advanced companion you can use *Cosmology* by D. Baumann.

We will use the canvas system for in-class assignments, so please bring an electronic device (smartphone, laptop, tablet) with access to canvas to class.

### CLASSROOM EXPECTATIONS

**Class attendance and participation** is crucial for understanding the complex material we will be covering. Additionally, we will be doing group exercises in class. These exercises are important for building your understanding and intuition about difficult problems. I always welcome questions about the course material during class (or at office hours).

Absences for illness, religious observances, participation in University activities at the request of University authorities, and compelling circumstances beyond the student's control are excused under University policy. According to UT Austin policy, you must notify the professor of a pending absence at least fourteen days prior to the date of observance of a religious holy day. If you must miss a class, an examination, a work assignment, or a project in order to observe a religious holy day, you will be given an opportunity to complete the missed work within a reasonable time after the absence.

My official responsibilities as a professor occasionally require me to participate in external events. I will do my best to ensure these events do not conflict with class time; if I do have to miss any instructional time, another PhD UT astronomer will lead the class. In general, classes will not be recorded, unless unforeseen circumstances require it.

**Respect for others is vital.** I am invested in the educational experience of each student in the class, respectful of individual differences, encouraging of creativity, available to discuss material and assignments; thorough in evaluating assignments; and rigorous yet supportive in maintaining high standards for performance. As a student, you are expected to work individually and with others, to create an atmosphere that is safe, valuing of one another, and open to diverse perspectives. Everyone is expected to show courtesy, civility, and respect for one another. Comments or postings that degrade or ridicule another, whether based on individual or cultural differences, are unacceptable.

**Sharing of Course Materials is Prohibited.** No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

## ASSIGNMENTS

You will receive the grade you earn in this course. **There will be no extra credit awarded during or after the semester**, so please be sure to put in the effort during the semester to earn the grade you want. Your grade will be based on the following components:

1. Homework (assigned through canvas roughly every 2 weeks). On each due date, homework should be handed in at the beginning of the class; it will be considered late by the end of class. Late homework will be accepted for a week after the due-date and will be subjected to a penalty of up to 30%. Your first delay is free, and the lowest homework grade will be dropped. If you have a valid emergency that prevents you from making a homework deadline, you should make all reasonable efforts to contact me before the due date; a self-signed note is sufficient provided that it contains a statement that (1) the information is true and correct and (2) you are aware that providing false information is prohibited under the Code of Student Conduct. If, for any reason, the University is officially closed on the day of the due date, the due date will be moved to the next lecture. Worth 40%.
2. In-class quizzes (roughly weekly, through canvas). These will be unannounced and take about 10 minutes. They are designed to reinforce important concepts in the class. Your 10 lowest quiz questions will be dropped (about 2.5 weeks worth of quizzes). If you must be absent for an extended period or miss more than 2 weeks, please arrange to discuss this with me. Worth 30%.

- Final project. In place of a final exam, you will submit a project related to a topic of active research in cosmology. You will be evaluated based on your demonstrated knowledge of the topic's techniques, current status, and future prospects. The project will be due on the last week of classes (week of December 4<sup>th</sup>) and will involve figures in addition to text. Worth 30%.

The following table represents how you will demonstrate your learning and how we will assess the degree to which you have done so.

Assignments (summary)	Percent of Total Grade
1. Homework	40%
2. In-class quizzes	30%
3. Final project	30%

### GRADE BREAKS

Grade	Cutoff
A	94%
A-	90%
B+	87%
B	84%
B-	80%
C+	77%
C	74%
C-	70%
D+	67%
D	64%
D-	60%
F	<60%

Grades are rounded to the nearest hundredth (0.01%) as per standard UT policy.

## Preliminary Course Outline

All instructions, assignments, readings, rubrics and essential information will be on the Canvas website at [utexas.instructure.com](https://utexas.instructure.com). Check Canvas regularly. **Changes** to the schedule may be made at my discretion if circumstances require. I will announce any such changes in class and will also communicate them via a Canvas announcement. It is your responsibility to note these changes when announced, and I will do my best to ensure that you are notified of changes with as much advance notice as possible.

Week	Date	Class Topic
1	Aug 21-25	Cosmological scales and units (reading Ch. 1 and 2)
2	Aug 28, Sep 1	The expanding universe, redshift (Ch 2)
3	Sep 6, 8	Distances, FRW metric (Ch 3.2, 3.4-3.6) ( <b>Sep 4 is Labor day, no class</b> )
4	Sep 11-15	Basic equations of cosmology, curvature, acceleration (Ch 4)
5	Sep 18-22	Model universes, the concordance LCDM model (Ch 5)
6	Sep 25-29	Standard candles/rulers, the cosmic timeline (Ch 6)
7	Oct 2-6	Big Bang nucleosynthesis and the first elements (Ch 9)
8	Oct 9-13	The cosmic microwave background (Ch 8)
9	Oct 16-20	Inhomogeneities and the growth of fluctuations (Ch 11)
10	Oct 23-27	Structure formation, galaxy surveys, baryon acoustic oscillations (Ch 11)
11	Oct 30-Nov 3	The first galaxies and cosmic reionization (Ch 12)
12	Nov 6-10	Dark matter (Ch 7)
13	Nov 13-17	Cosmic Inflation (Ch 10)
14	Nov 20-24	<b>Fall break/Thanksgiving – no class</b>
15	Nov 27-Dec 1	Outstanding issues and future directions, final projects
16	Dec 4	Final projects, feedback ( <b>last class day</b> )

See <https://registrar.utexas.edu/calendars/23-24> for the UT calendar for this academic year.

## Course Policies and Disclosures

### ACADEMIC INTEGRITY EXPECTATIONS

Students who violate University rules on academic misconduct are subject to the student conduct process and potential disciplinary action. A student found responsible for academic misconduct may be assigned both a status sanction and a grade impact for the course. The grade impact could range from a zero on the assignment in question up to a failing grade in the course. A status sanction can range from probation, deferred suspension and/or dismissal from the University. To learn more about the academic integrity standards, tips for avoiding a potential academic misconduct violation and the overall conduct process, please visit the Student Conduct and Academic Integrity website at: <http://deanofstudents.utexas.edu/conduct>.

**On NLMs and ChatGPT:** Incorporating NLMs (like ChatGPT) into your learning can offer valuable insights, but it's crucial to exercise caution and responsibility. While ChatGPT can assist in brainstorming, generating ideas, and clarifying concepts, it should not replace rigorous research and critical thinking. For this course, **every word written in an assignment ought to be written by you**, even if you use ChatGPT for inspiration/ideas/cross checks.

## NAMES AND PRONOUNS

Class rosters are provided to the instructor with the student's legal name, unless they have added a "chosen name" with the registrar's office, which you can do so [here](#). I will gladly honor your request to address you by a name that is different from what appears on the official roster, and by the pronouns you have asked to be used for you (she/he/they/ze, etc). Please advise me of any changes early in the semester so that I may make appropriate updates to my records. For instructions on how to add your pronouns to Canvas, visit [this site](#). Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender identity & expression, and nationalities. More resources available on the Gender and Sexuality Center's website, [www.utgsc.org](http://www.utgsc.org).

## LAND ACKNOWLEDGMENT

I would like to acknowledge that we are meeting on the Indigenous lands of Turtle Island, the ancestral name for what now is called North America. Moreover, I would like to acknowledge the Alabama-Coushatta, Caddo, Carrizo/Comecrudo, Coahuiltecan, Comanche, Kickapoo, Lipan Apache, Tonkawa and Ysleta Del Sur Pueblo, and all the American Indian and Indigenous Peoples and communities who have been or have become a part of these lands and territories in Texas.

## TITLE IX DISCLOSURE

Beginning January 1, 2020, Texas Education Code, Section 51.252 (formerly known as [Senate Bill 212](#)) requires all employees of Texas universities, including faculty, report any information to the [Title IX Office](#) regarding sexual harassment, sexual assault, dating violence and stalking that is disclosed to them. Texas law requires that all employees who witness or receive any information of this type (including, but not limited to, written forms, applications, one-on-one conversations, class assignments, class discussions, or third-party reports) must report it to the [Title IX Coordinator](#). Before talking with me, or with any faculty or staff member about a Title IX related incident, please remember that I will be required to report this information.

Although graduate teaching and research assistants are not subject to Texas Education Code, Section 51.252, they are [mandatory reporters](#) under federal Title IX regulations and are required to report [a wide range of behaviors we refer to as sexual misconduct](#), including the types of misconduct covered under Texas Education Code, Section 51.252. Title IX of the Education Amendments of 1972 is a federal civil rights law that prohibits discrimination on the basis of sex – including pregnancy and parental status – in educational programs and activities. The Title IX Office has [developed supportive ways](#) and compiled [campus resources](#) to support all impacted by a Title IX matter.

If you would like to speak with a Case Manager for Support and Resources, who can provide support, resources or academic accommodations, in the Title IX Office, please email [supportandresources@austin.utexas.edu](mailto:supportandresources@austin.utexas.edu). A Case Manager can also provide support, resources and accommodations for pregnant, nursing, and parenting students.

For more information about reporting options and resources, visit <http://www.titleix.utexas.edu/>, contact the Title IX Office via email at [titleix@austin.utexas.edu](mailto:titleix@austin.utexas.edu), or call 512-471-0419.