



This is one slice through the map of the large-scale structure of the Universe from the Sloan Digital Sky Survey and its Baryon Oscillation Spectroscopic Survey. Each dot in this picture indicates the position of a galaxy 6 billion years into the past. The image covers about 1/20th of the sky, a slice of the Universe 6 billion light-years wide, 4.5 billion light-years high, and 500 million light-years thick. Color indicates distance from Earth, ranging from yellow on the near side of the slice to purple on the far side. Galaxies are highly clustered, revealing superclusters and voids whose presence is seeded in the first fraction of a second after the Big Bang. This image contains 48,741 galaxies, about 3% of the full survey dataset. Grey patches are small regions without survey data. *Image credit:* Daniel Eisenstein and the SDSS-III collaboration.

## Syllabus for Astronomy 0001: *Survey of the Universe*, Fall 2022

**Course meetings:** TR 10:15-11:45 am in [DRL 3N1H](#) (Section 2)

**Instructor:** [Prof. Robyn Sanderson](#) - **Office:** DRL 4N10

**IMPORTANT: Only one ASTR course below ASTR211 (this includes ASTR001, ASTR003, ASTR006, and ASTR007) may be taken for credit. Engineering students receive no credit for this course.**

Welcome to *Survey of the Universe*! I look forward to sharing my favorite subject with you this semester. You may find some material challenging, but I hope you will also be inspired and amazed by what you learn.

By the end of the course, you will be able to:

- A. Use proportionality in simple algebraic expressions
- B. Deal with very small and very large numbers using logarithmic scales, orders-of-magnitude reasoning, exponential notation, and unit conversion
- C. Assess whether an investigation follows scientific principles
- D. Interpret astronomical images, spectra, and 2D scatter plots
- E. Relate the scales of different structures in the universe to one another
- F. Combine and draw conclusions from different sources of information about the universe
- G. Understand which basic physical principles govern different astronomical phenomena
- H. Catalog the fundamental types of matter and energy in the universe and their properties
- I. Tell the story of the universe from its birth to the present day
- J. Trace the production and assembly of the ingredients for life on Earth
- K. Explain to your friends & family why *you* think astronomy is cool

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It's important to me that everyone who wants to participate has the [resources](#) to be fully included in this course. Please let me know if you need special accommodations in the curriculum, instruction or assessments of this course to enable you to participate fully. I will make every effort to maintain the confidentiality of the information you share with me.

Penn provides reasonable accommodations to students with disabilities who have self-identified and been approved by [Student Disabilities Services](#) (SDS). If you have not yet contacted SDS and would like to request accommodations or have questions, you can make an appointment by calling SDS at 215-573-9235. The office is located in the [Weingarten Learning Resources Center](#) at Stouffer Commons: 3702 Spruce Street, Suite 300. All services are confidential.

## You will need:

A **computer** that:

- Has an internet connection fast enough to stream or download the video lectures
- Has a secure [web browser that is supported by Canvas](#)
- Satisfies the [system requirements for Canvas](#)

Some way to **submit your work electronically**:

- If you don't want to type all your assignments, you can use a **smartphone camera** to scan/photograph handwritten work, either [using built-in apps](#) or [using a free third-party scanner app](#) ([broader list including paid and free options](#)). You don't need Optical Character Recognition (OCR; converts handwriting into typed text). See these [guidelines for making a legible photo](#).
- At libraries and copy centers, **copy machines will often also scan documents** and email them to you as a PDF, which you can then submit.
- Or you can **type everything on a word processor** - [Microsoft Word now allows you to typeset equations in LaTeX](#), and [so does LibreOffice](#) (an [open source alternative](#) to Microsoft Office)

## You may also want:

[Bennett, Donahue, Schneider, & Voit, \*The Cosmic Perspective\*](#) (the course textbook)

We follow approximately the order and contents of this book, which offers alternative explanations of the concepts covered in the course. However, **you will be responsible for learning only material covered in the lectures**, so you are **not required to purchase** it. You can see the opinions of previous years' students about the textbook, from their midterm survey, [here](#).

If you do buy the book, either the [E-text](#) (ISBN-13: 9780135161753) or [physical copy](#) (ISBN-13: 9780134874364) is fine. The 9th (most recent) or 8th edition (~\$100 cheaper) will suffice. You do not need to purchase a “Mastering Astronomy” license. Be sure not to order only Part I (“The Solar System”) or Part II (“Stars & Galaxies”) or “The *Essential* Cosmic Perspective” (doesn’t cover everything), all of which are sold separately (check the ISBN).

[Those for whom acquiring the book poses financial difficulties can find help getting a copy here.](#)

## Course Components

**This course will be taught in a “flipped” format**, with a combination of asynchronous and synchronous work:

- **Video lectures, slides, and comprehension quizzes** will be posted prior to each class meeting date. These can be viewed **asynchronously** and should be completed **before the lecture date**. The material about a concept is referred to as a “module.”
- **The first hour** of the class meeting periods will generally be used as **problem-solving sessions** where students will work in small groups to practice solving problems similar to what will be on the quizzes and in the homework. Each of these sessions covers the concepts in one module, for an average of 2 modules per week. The topics of these sessions are indicated in the [course schedule](#).
- **The final half hour** of class will be like **office hours**: we’ll review material covered in the prior week and take questions about lectures, in-class problems, homework, and quizzes.
- One multipart **homework** problem will be assigned for each module, due approximately 1 week after we cover that module in a problem-solving session. For the first 8 modules, all homework is required; after that you may generally choose 1 of every 2 assignments to submit for credit with a few exceptions toward the end of the course. Due dates are summarized in the [course schedule](#) and in the [homework tracker](#).
- **A total of 3 quizzes will be given in class**, about one every 3-4 weeks, to test your independent understanding of the material. For the quizzes, you will need **pen or pencil only (no electronics of any kind)**. You will be able to bring a notes sheet with you (2-sided, 8.5”x11” paper). Quiz dates are highlighted in **yellow** in the [course schedule](#).
- A **final project** will take the place of a final exam. Stay tuned for more information!

## Communication

- **From me to you**: check for announcements on Canvas, email, and Slack at least once between sessions. I will also make announcements at the start of class.
- **From you to me**: [use the Canvas Inbox to contact me](#). Don’t count on my replying quickly to messages: expect a response **within 2 business days** (i.e. not on weekends). You will have better luck on the [Slack workspace](#) for homework help and lecture questions, which the TA or I will check at least once a day (more frequently near quiz times).
- **From you to you**: you will also be able to answer each other’s questions using [Slack](#). I expect you to follow the guidelines [provided in the syllabus](#) to keep our online discourse inclusive of and useful for everyone.

## Course Schedule

An [expanded, live updated version of this schedule](#) is available.

week	date*	module #	topics	notes
<b>* recorded lectures on the listed topics will be available at least 3 days before, and should be viewed by, this date</b>				
1	<b>29 August</b>	0	<b>How to get an A in ASTR001</b>	<b>to be completed before first class</b>
	30 August	1	Intro to the course; the scientific method; scales of the universe	
	1 September	2	the night sky; seasons; phases of the Moon; eclipses	
2	6 September	3	Laws of planetary orbits; velocity, acceleration, force, & momentum	
	8 September	4	The law of gravitation; the 3 laws of motion; conservation laws: energy, momentum, angular momentum	
3	13 September	5	circular & escape velocity; tides & resonances	Course selection period ends
	15 September	6	light as a wave (frequency & wavelength); light as a particle (energy); interactions of light & matter	
4	20 September	7	thermal radiation; the doppler effect; telescope design	
	22 September	8	4 major features of the Solar System; formation of planetary systems; the age of Solar system	
5	<b>27 September</b>	<b>Q1</b>	<b>Quiz on modules 1-7</b>	<b>during class</b>
	29 September	9	how to discover exoplanets; new kinds of planets; what makes a planet "habitable"	
6	4 October	10	life on Earth & other worlds	
	<b>6 October</b>	<b>--</b>	<b>no class - Fall Break</b>	Drop period ends (10th)
7	11 October	11	what powers the Sun; the structure of the Sun; observing the Sun (seismology, solar activity, neutrinos)	
	13 October	12	main-sequence stars: brightness, distance, mass, size; luminosity, temperature, and the HR diagram	

8	18 October	13	stellar lifetimes; star formation	
	20 October	14	stellar evolution for low-mass stars; stellar evolution for high-mass stars	
9	25 October	15	stellar graveyard: WD; NS; BH	Grade type change deadline (28th)
	<b>27 October</b>	<b>Q2</b>	<b>Quiz on modules 8-14</b>	<b>during class</b>
10	1 November	16	special relativity; general relativity	
	3 November	17	relativistic astrophysics (BH binaries; GL; GW)	Last day to withdraw (7th)
11	8 November	18	structure & contents of the Milky Way; the invisible Galaxy (BH and DM)	
	10 November	19	gas and dust in MW-like galaxies and the cycle of star formation; MW formation & chemical "clocks"	
12	15 November	20	other kinds of galaxies; how galaxy formation differs with mass; voids, groups, & clusters	
	17 November	21	galaxy interactions; active galaxies	
13	22 November	22	the distance ladder parts 1 (intragalactic) & 2 (intergalactic)	
	<b>24 November</b>	--	<b>No class - Thanksgiving break</b>	
14	<b>29 November</b>	<b>Q3</b>	<b>Quiz on modules 15-21</b>	<b>during class</b>
	1 December	23	isotropy, homogeneity, & the dark night sky; big bang theory; the cosmic microwave background	
15	6 December	24	dark matter; the large scale structure of the universe	
	8 December	25	inflation; dark energy; challenges and alternatives for LCDM	
finals	13 December	--	Reading days begin	
	15 December	--	Finals begin	
	<b>20 December</b>	--	<b>Final project due</b>	

## COVID Precautions

In order to keep everyone as safe as we can, please respect the following [precautions](#):

- **Get vaccinated.** This is required by Penn for all students, faculty, and staff, with few exceptions.
  - **If you feel sick or were exposed to COVID, get a test:** The University offers on-campus Covid testing to all students on demand and at no cost regardless of vaccination status. To schedule a voluntary Covid test, please go to [this website](#) and click on the “Schedule a Test” link. The SAS Dean’s office strongly encourages all students to take advantage of this free service at any time, especially if you are feeling ill or believe that you have been exposed to someone who has Covid.
  - **If you test positive for COVID, please do not come to class or office hours.** Specifically, please participate remotely for [5 days after a positive COVID test](#). Let me know you’ll miss class by filing a [Course Absence Report](#) through [Penn InTouch](#), keep up with the material online, and follow up with me to make up assignments as needed. **Your grade in this class will not be penalized for precautions to protect each other from COVID.**
  - **I will wear a mask** during class to protect you and myself.
  - **You are invited to [wear a mask](#) in class if you:**
    - want to for any reason
    - are immunocompromised and personally at high risk
    - are in frequent close contact with someone who is high risk
    - tested positive for COVID-19 more than 5 but less than 10 days ago (if less than 5 days, please participate remotely)
    - have been exposed to someone with COVID-19
    - have recently traveled to an area with substantial or high spread of the virus
- Please respect the choices of your classmates. If you feel targeted or uncomfortable in class, speak with me or the TA.**
- **[Wash your hands](#)** when you change your space: when you arrive at your first class, between classes, after you ride public transportation, when you get home/back to your dorm.

## Getting Help

This course is intended to challenge and expand your ability to solve problems using mathematical expressions, to reason using numbers, and to interpret various types of quantitative astronomical data. The approaches you will learn are new to most people who take this class, so if you run into difficulty, **you are not alone**. You have many options for getting additional practice. Here are some resources you can turn to for help:

**Office hours:** asking questions and getting help on your classwork is precisely what office hours are for! We will offer at least 3 office hours per week in addition to the final half hour of each class period, scheduled so that at least one is available to everyone. **Office hours will always have a virtual option** to ensure maximum accessibility. If discussing a homework problem with ~10-15 other students around still sounds intimidating, feel free to observe a few sessions and you will most likely see that everyone else is asking the same kinds of things you are wondering about!

**Your small group partners:** you’ll be assigned to a group of 4 students for our problem-solving sessions. We will do some activities on the first day for you to get to know each other a little, so you feel a bit more comfortable asking for help from each other outside those sessions. Don’t hesitate to give help to other

people when asked, even if you're not entirely sure of the right answer: ***the best way to learn something is to teach it!***

**Slack workspace:** I've set up discussion boards where the whole class can discuss questions on the homework sets and concepts from lectures, and ask and answer questions of each other. The TA and I will monitor these to clarify confusing points and correct common misconceptions.

**Math and physics help:** the Math Department offers **free** [drop-in Math & Physics help](#) multiple times per week. Getting problem-solving help for this class usually falls in their areas of expertise.

**General learning resources:** Penn's [Weingarten Learning Resource Center](#) offers **free**: [professional instruction in study skills](#), comprehensive [services for equal access to learning](#) for students with disabilities (self-identified), and [tutoring services](#) (the Math and Physics tutors will likely be able to help you, and I have heard they will offer Astro tutors this semester as well).

**Mental health resources:** If you broke your leg, you'd go to a doctor. If your mental health needs attention, take it just as seriously. [Penn Counseling and Psychological Services](#), the [Penn Office of the Chaplain/SPARC](#), and the [Penn Reach-A-Peer Helpline](#) offer **free** help.

**Financial assistance:** Penn offers [emergency and opportunity funding](#) to help students cope with unexpected or unmanageable expenses (such as a broken laptop, winter or professional clothing, application and testing fees, or medical expenses). **Any** enrolled undergraduate, graduate, or professional student is potentially eligible for this financial assistance. Students do **not** need to identify as FGLI or highly aided to apply.

## Academic Integrity

Participants are expected to abide by the [Penn Code of Academic Integrity](#) in letter *and* spirit. Scientific research is a collaborative endeavor that depends on proper acknowledgment of each person's contributions to a project: this holds in this course as it does in general.

“Creating a supportive environment to enable scientific discourse ... is the responsibility of all participants.”

American Physical Society,  
*Code of Conduct for APS Meetings*

**Fostering an inclusive atmosphere in scientific discussions is an integral part of academic and professional ethics.** Participants are expected to abide by the [Penn Code of Student Conduct](#) during course activities, and to use the following guidelines as a standard of behavior<sup>1</sup>:

### Expected Behavior

- Be considerate, respectful, and collaborative.
- Critique ideas rather than individuals.
- Avoid personal attacks directed toward other participants.
- Be mindful of your surroundings and of your fellow participants.
- Respect the rules and policies of our online classroom in [Canvas](#), Slack, and [Zoom](#).

### Unacceptable Behavior

- Harassment, intimidation or discrimination in any form will not be tolerated.
- Physical, verbal, or online abuse of any participant will not be tolerated.
- Examples of unacceptable behavior include, but are not limited to: verbal or online comments related to gender, gender identity and expression, sexual orientation, disability, physical appearance, body size, race, religion, national origin, as well as inappropriate use of nudity and/or sexual images, and threatening or stalking any participant.
- Recording or photographing another individual without their explicit permission is not allowed.

### Consequences

- Anyone requested to stop unacceptable behavior is expected to comply immediately.
- The course instructor may take any action deemed necessary and appropriate, including immediate removal from a class session or the course, or referral to university disciplinary procedures.

### Reporting Unacceptable Behavior

- If you are the subject of unacceptable behavior or have witnessed any such behavior, please immediately notify the instructor.
- Anyone experiencing or witnessing behavior that constitutes an immediate or serious threat to public safety should contact campus security at **215.573.3333**.

Any member of the Penn community can call the Penn HELP line<sup>2</sup> at any time to be connected with staff trained for mental health referrals:

**215-898-HELP(4357)**

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<sup>1</sup> Adapted from the [Ecological Society of America meeting code of conduct](#).

<sup>2</sup> <https://www.publicsafety.upenn.edu/safety-initiatives/help-line-215-898-help/>

## Evaluation

Assignments are designed to help you confirm that you understood the material, give opportunities to practice what you learned, and offer feedback on areas for improvement.

**RULE ZERO: DO NOT EMAIL ME ANYTHING IMPORTANT OUTSIDE OF THE CANVAS INBOX. IT WILL FALL INTO A BLACK HOLE AND DISAPPEAR FOREVER.**

The evaluations are structured so that if you miss an exercise (homework, group work, quizzes) occasionally for whatever reason, it will not significantly affect your grade, so **no late work will be accepted** (electronic submission will be inaccessible after the deadline; email submissions fall under Rule Zero). Solutions to problems will be available after the deadlines where applicable, if you haven't already looked them up online (hint: it's about the journey, not the destination).

**Comprehension quizzes:** these will follow each recorded lecture. They're designed to check whether you understand the material covered in the recorded lecture (so it's kind of pointless to cheat). If you choose the wrong answer you'll get some information as to why it's wrong and can choose another answer till you get it right. These are **graded on completion**.

**In-class problems:** you will work in groups of 4 to solve a problem, with help available from me and the TA. The role of "scribe" will rotate among your members over the semester; this person will submit the solution arrived at by the whole group. A **good-faith effort gets full credit** even if you don't get the right answer. The lowest of your scores on the in-class problems will be dropped when calculating your grade (effectively this means you can be absent from one class if you need to be for whatever reason).

**Homework:** One multi-part exercise on the topic covered in each module. **One of every two homework problems will be submitted for a grade**, with a few exceptions. The other can optionally be submitted for additional feedback and practice, but will not count toward your grade. An **electronic** copy is due approximately 1 week after the class in which it's covered (you can type up your solution, or scan a handwritten one if you think I can read it). Evaluated as follows:

- 0 points:** didn't submit anything
- 1 point:** wrote down *something* relevant, but didn't get very far
- 2 points:** had the right idea but not the correct answer
- 3 points:** showed work leading to an entirely correct solution

The lowest of your homework scores will be dropped when calculating your grade.

**Quizzes:** In lieu of exams, your independent comprehension of the material will be tested on 5 non-cumulative quizzes each lasting 1 class period (1 hour). These will be very similar to the problems you solved in groups during class, and less involved than the homework problems. Quizzes will be **closed-book, no electronic devices** permitted (we'll keep track of time for you). You will be allowed a single double-sided 8.5x11 sheet of **notes** and will be provided with a **formula sheet**. The lowest of your 5 quiz scores will be dropped when calculating your grade.

**Final project:** you will demonstrate your cumulative understanding of the material in a final project, due on the final exam date.

### Grading summary

<b>Comprehension quizzes</b> (graded on completion)	<b>10%</b>
<b>In-class group work</b> (graded on good-faith effort, lowest score dropped)	<b>30%</b>
<b>Homework</b> (one problem per module graded out of 3, lowest score dropped)	<b>25%</b>
<b>Quizzes</b> (5 available, lowest score dropped)	<b>25%</b>
<b>Final Project</b>	<b>10%</b>

## Acceptance of Syllabus & Code of Conduct

*Please sign, detach, and return this part at the start of the first class you attend.*

I have read and understood the syllabus for ASTR 0001 Section 2, Fall 2022. In all matters pertaining to this course, I agree to abide by Penn's Code of Academic Integrity and the course code of conduct, as specified in the "[Academic Integrity](#)" section of the syllabus. I accept that my participation in this course is contingent on following these policies.

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Signature

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Date

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Printed Name

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PennKey