

Astronomy 142: The Evolving Universe

University of Montana, Spring 2020

MWF 2:00 – 2:50 pm, DHC 117

Tu 2:00 – 3:50 pm, CHCB 230

Course Number 31188

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Office Hours: MW 11a-12p, F 1-2p and by appointment

Course Description

In Astronomy 142, we'll study our amazing, dynamic and varied Universe. We'll investigate our place in the Universe, and how we got here. We'll examine the night sky and the tools we use to study it. We'll explore the Solar System, probe the interiors of planets and learn the techniques used to detect exoplanets orbiting distant stars. We'll speculate about astrobiology and the prospects of life elsewhere in the Universe. We'll learn about the births, lives and spectacular deaths of stars. We'll consider familiar objects like our star (the Sun), more fantastic things like quasars, exploding supernovae and the expanding Universe, and things we cannot even see like supermassive black holes, dark matter and dark energy. Our studies will take us from the very small scale of subatomic particles to the largest scale of all: the primordial cosmic microwave background radiation that fills the Universe! Along the way we'll discover how the Universe began, how it is changing, and its final fate, and examine the many ways astronomers piece together this wondrous puzzle.

Course Objectives

My goals in this course are to...

1. Convey the framework and basis of our understanding of the Universe.
2. Demonstrate that the Universe is dynamic and ever changing.
3. Establish that the Universe is knowable through the process of science and that physical laws are universal.
4. Build understanding of fundamental physical properties and phenomena.
5. Prepare students for upper division astrophysics courses.

Required Materials

Astronomy Labs

by N. McCrady and E. Rice

This is a custom edition for Astr 142N, available through the UM Bookstore.

Astronomy

by A. Fraknoi, D. Morrison and S. Wolff

This OpenStax textbook is available FREE(!) at <https://openstax.org/details/books/astronomy>

Expectations of the Professor

This is an honors university science course that offers an intensive learning environment for motivated undergraduates. The pre-requisite is a working knowledge of precalculus (algebra and trigonometry). Time in the classroom is an essential part of this course, and it will be to your benefit to attend class meetings. Group work is an integral part of your learning experience, and you must be present to benefit. Quizzes will be based on material presented in class and the lab activities. This course is a collaborative effort – please ask questions, offer your opinions and ideas, and be prepared to participate in the discussion.

At UM, one “credit” represents three hours of work by the student. This is a four-credit course, so you can expect to put 12 hours of work into the course each week, including time in class. I strongly recommend that you complete the day’s reading assignment before attending class.

Classroom Activities

Being actively involved in class activities will help you learn better. That is why I'm going to such effort to provide opportunities for you to engage! Your role in this class is to actively participate and take charge of your own learning. This means reading the relevant sections of the textbook before each class meeting, asking questions, discussing the material and activities with other students in class, and coming to office hours if you are struggling. My role as the instructor is to find ways to help you learn, show illustrative examples, ask you questions to find out what is confusing you, be available for and answer your questions, and provide lots of tools, feedback, and ways for you to assess your own learning.

Astronomy is a varied field, and as such we will approach the course material in a variety of ways. Most days will include a discussion of new material as listed on the course schedule in this syllabus. On Mondays, class will begin with a 10 minute quiz over material from the previous week. Tuesdays are the 2-hour lab class, with small group lab activities on the topic of the week. On Wednesdays, a pair of students will present a topic from an Astrobites article. Fridays will feature a small group order-of-magnitude estimation problem, worked in class with no access to other information sources. During the semester, weather permitting, we will also use the university’s 0.4-meter telescope to observe the night sky from campus.

Grading Policy

This course will be graded on the University’s traditional letter grade system. Your grade will be based on your performance as weighted below. I have not chosen in advance how many As, Bs, etc to award – you will get the grade you earn regardless of the grades of your classmates. You are most certainly **NOT** competing with each other for grades! Do work together – you will learn a lot from your peers.

Homework	25%
Labs	25%
Quizzes	25% (total)
Participation	15%
Final exam	10%

There will be ten quizzes, each 10 minutes in length, scheduled at the beginning of class on Mondays. Each quiz represents 2.5% of your course grade. There will be ~14 lab activities, typically conducted during the Tuesday afternoon lab sessions. Homework problems are due in class on Fridays. Late homework will be penalized 10% per school day to a minimum of 50% credit. Your participation grade will consist of an oral report to the class (5%) and your solutions to the 10 in-class order of magnitude estimation problems (1% each). The final exam will summarize the material from the quizzes, and will be cumulative for the full semester. Updates on your performance in the course will be available on the course Moodle page during the semester so that you always know where you stand.

Disability Policy

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students (DSS). If you think you may have a disability affecting your academic performance, and you have not already registered with DSS, please contact DSS in Lommasson 154. I will work with you and DSS to provide an appropriate accommodation to facilitate your learning.

Course Schedule

			Readings
M	Jan 13	What's in a Day: Solar and Sidereal Rotation	pp 31-35
T	Jan 14	Lab: Night sky motions (UM Planetarium)	
W	Jan 15	Night sky motions	pp 36-41
F	Jan 17	Order of magnitude estimation in science	
M	Jan 20	<i>Martin Luther King, Jr. Holiday</i>	
T	Jan 21	Lab: Constellations and seasons (UM Planetarium)	
W	Jan 22	Energy and light	pp 145-156
F	Jan 24	Inverse square law of light	
M	Jan 27	Telescopes and observatories	Chapter 6
T	Jan 28	Lab: Observatories Around the World	
W	Jan 29	Kepler's laws of planetary motion	Section 3.1
F	Jan 31	Gravity and orbital motion	Sections 3.2 – 3.3
M	Feb 3	Solar system: terrestrial planets	Sect 7.1, Ch 9, 10
T	Feb 4	Lab: Gravity and Orbital Motion	
W	Feb 5	Solar system: rocky bodies	Chapter 13
F	Feb 7	Solar system: gas giants	Chapter 11
M	Feb 10	Planetary composition	Section 7.2
T	Feb 11	Lab: Bulk Density and Planet Composition	
W	Feb 12	Exoplanets: Transit detection	Section 21.4
F	Feb 14	Exoplanets: Doppler detection	Section 21.5
M	Feb 17	<i>Presidents Day Holiday</i>	
T	Feb 18	Lab: RV and Exoplanets: The Doppler Technique	
W	Feb 19	Astrobiology: Habitable Zone	Chapter 30
F	Feb 21	Astrobiology: the Drake Equation	
M	Feb 24	Spectroscopy	Sections 5.3 – 5.5
T	Feb 25	Lab: Spectroscopy	
W	Feb 26	Energy & matter	pp 157-160
F	Feb 28	Sun as a star	Section 15.1
M	Mar 2	Nuclear energy in the Sun	Section 16.1
T	Mar 3	Lab: Nuclear Fusion and Energy in Stars	
W	Mar 4	Solar interior and structure	Section 16.2
F	Mar 6	Properties of stars	Sections 17.1 – 17.2
M	Mar 9	Hertzprung-Russell diagram	Ch 18, Sect 19.4
T	Mar 10	Lab: Stars and the H-R Diagram	
W	Mar 11	Binary stars and stellar masses	Section 18.2
F	Mar 13	Variable stars and cosmic distances	Section 19.3

Spring Break

M	Mar 23	Interstellar medium	Chapter 20
T	Mar 24	<i>No lab meeting this week</i>	
W	Mar 25	Star formation	Sections 21.3 – 23.3
F	Mar 27	Main sequence lifetime, M-L relation	Sections 22.1 – 22.3
M	Mar 30	Post main-sequence evolution and red giants	Section 22.4 – 22.5
T	Mar 31	Lab: Star Clusters and the Ages of Stars	
W	Apr 1	Stellar endpoints: white dwarfs & supernovae	Chapter 23
F	Apr 3	Exotic remnants: neutron stars & black holes	Chapter 24
M	Apr 6	Contents of the Milky Way	Chapter 25
T	Apr 7	Lab: Mapping the Milky Way Galaxy	
W	Apr 8	Morphology of galaxies	Sect 26.1 – 26.4
F	Apr 10	Hubble law	Section 26.5
M	Apr 13	Active galactic nuclei and quasars	Chapter 27
T	Apr 14	Lab: Hubble law and the Expansion of the Universe	
W	Apr 15	Galaxy evolution	Sections 28.1, 28.5
F	Apr 17	Dark matter	Section 28.4
M	Apr 20	Our expanding Universe	Section 29.1
T	Apr 21	Lab: Expansion and the Age of the Universe	
W	Apr 22	Cosmic microwave background	Section 29.4
F	Apr 24	Big Bang nucleosynthesis	Section 29.5
M	Apr 27	Expansion history of the Universe	Section 29.2
T	Apr 28	Lab: Accelerating Expansion of the Universe	
W	Apr 29	Distant supernovae and dark energy	Section 29.5
F	May 1	Course review	
W	May 6	Final Exam, 3:20 – 5:20 pm	

Additional Reading Material

The free textbook we will use in this course is encyclopedic, and touches on most topics in astronomy. If you would like to extend your reading at the popular science level, here are some that I recommend.

NightWatch: A Practical Guide to Viewing the Universe, by Dickinson (stargazing in your backyard)

Bright Star Atlas, by Tirion (easy to use maps of the night sky)

The Stars: A New Way to See Them, by Rey (a constellation guide, more aimed at kids but a total classic)

A Student's Guide to the Mathematics of Astronomy, by Fleisch & Kregenow (a tutor in your pocket)

The Backyard Astronomer's Guide, by Dickinson (a guide to buying and using a small telescope)

The Martian, by Weir (fictional, but the science is great – a look at human travel to Mars)

How I Killed Pluto and Why It Had It Coming, by Brown (a great look at how astronomers work)

How do You Find an Exoplanet?, by Johnson (an insider's guide to the techniques of planet hunting)

Cosmos, by Sagan (a classic book – and TV series – that launched the careers of many astronomers)

Welcome to the Universe, by Tyson, Strauss & Gott (a guided tour of the cosmos as of 2016)

Black Holes & Time Warps, by Thorne (a terrific book about exotic objects, worm holes, time travel)

Cosmic Catastrophes, by Wheeler (modern astronomy relating to gamma ray bursts, supernovae, etc.)

A Brief History of Time, by Hawking (cosmology and the history of the Universe, a classic book)

The Elegant Universe, by Greene (great summary of contemporary astrophysics, plus string theory)