

Department of Astronomy and Planetary Science

AST 391 — Astrophysics: Stars

Fall 2021

Course Information

Meeting Times & Location: TTh 2:20 — 3:35 pm, HLC 4108

- Credit: 3 credit hours
- Instructor & Email: Dr. Lisa Chien
- Email: Lisa.Chien@nau.edu
- Office Location: Bldg. 19, Rm. 311
- Office Hours: all through emails please
- Grader: Hayden Piwonka (hep59@nau.edu)

This specific class is designed to be fully transparent, inclusive, and accessible to all students.

Course Prerequisites

AST 280 and PHY 263 (also PHY 265 preferred)

Course Description, Objectives, & Structure

This is an upper-level undergraduate course in stellar astrophysics, which is generally divided into two parts: the outsides of stars (*stellar atmospheres*) and the insides of stars (*stellar interiors*). The atmosphere component contains an introduction to radiative transfer, which is useful in all areas of astrophysics. The topic of *stellar evolution* is also covered. If time permits, related topics such as *star formation*, *star clusters* and *interstellar medium* will also be discussed.

At the end of this course, you should be able to

- i) explain the key concepts of stellar atmospheres, interiors, and evolution;
- ii) apply basic physics such as the Boltzmann and Saha equations;
- iii) write computer programs to explore and illustrate some of the key concepts;
- iv) interpret the output from those programs to demonstrate physical principles;
- v) comprehensively read articles in professional journals such as *Astronomical Journal*, *Astrophysical Journal*, *Annual Reviews of Astronomy and Astrophysics*, etc.
- vi) have an educated and intelligent conversation, with confidence and sincerity, to an astronomer.

*This will be a lecture course that includes group activities and small quizzes, reading assignments, homework of **writing small codes and using programs to plot** and interpreting the results of those programs, and exams.*

Textbook & Materials

- *An Introduction to Modern Astrophysics*, 2nd ed. by Carroll and Ostlie (*a.k.a.* BOB)
- *Foundations of Astrophysics*, by Ryden and Perterson (only Chapter 15, will be provided)
- **Calculator**
- **Laptop** or an accessible computer

- **Programming/graphing software** of your choice (free! See <https://in.nau.edu/its/software/>)—Microsoft Excel, MATLAB, Mathematica, Python, etc.
- **Internet connection**

Evaluation & Grading System

Classes missed	Effect on grade
≤ 3	None
4 — 6	Lowered by 5%
≥ 7	Lowered by 10%

Assessment	Points
Homework	175
Activity	150
Reading Quizzes	60
Midterm Exam	50
Final Exam	65
Total	500

Grade	Points
A	450 or more
B	400 — 449
C	350 — 399
D	300 — 349
F	0 — 299

i) Homework:

Homework can be submitted in-person or online on BBLearn. If you choose to submit online, please write them on papers and take high-resolutions pictures, or turn them into PDFs, for submission. Please submit only .jpg, .png, or .pdf files. For programming homework, please send the original .m, .py, etc files as well.

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- In order to receive full credit for computing problems, you need to turn in both your plots and code. Any plots must have 1) *a title*, 2) *axes labeled with units*, and 3) *legends if needed*. Your code needs to be *commented*. At the very least, the comments should include your name and the date, and what units each variable is carrying.
 - Late assignments will be accepted only with my *previous* permission. I know this is a hard time, and I will be very accommodating, but you have to work hard too. Please keep active and constant communication with me to let me know any extensions you need. **No credit will be awarded for homework after it is due.**
 - I encourage you to work with other students on the assignments, but **you must turn in your work in your own words, including any programming/plotting codes you wrote** (see Academic Integrity Policy below). Homework that is copied or suspiciously similar will receive a zero for *all students* involved.
 - This is the biggest part of your grade, so please **expect constant assignments and dues, and heavy workload during the semester**. If you have not taken a class that covers the basics (PHY 265, PHY 321 etc), I welcome you to work with me when you have difficulties. **No homework will be dropped.**

ii) Activity:

Almost every week we will have an (in-person or online) Activities. There are 15 Activities total, 12 Group Activities, either small or large, with the use of Google Slides and Google Sheets, and 3 individual activities on BBLearn. Each Activity is 10 points, so total is 150 points. No Activity points will be dropped.

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- Missing class will affect your grade according to the policy above. Documented illness and institutional excuses will be accepted.

- Please bring your laptop and/or calculator to in-person class as well.
- **I ask that you participate in-class at least once every class (ask a question, answer a question, make some intelligent, sensible sounds, etc)**, and I will keep track of that to make sure that everyone is participating and at the same pace.

iii) **Reading quizzes:**

All Reading Quizzes are administered and submitted online on BBLearn.

- This course requires A LOT OF physics and math, so in order to keep up with the class, **I strongly urge you to read the textbook, especially before the class.** Coming to class prepared is crucial since many of in-class exercises depend on your reading background.
- In order to guarantee that you do the reading, there will be **a reading quiz every time we finish a chapter (actual dates to be announced in class).** The quizzes are open-book and solely based on the textbook (in any format you have) during the reading quizzes. **You will only have 20 minutes to finish it**, so you need to know where your materials are.
- You can skip the sections that are not covered in the class, and I will not test you what is not discussed in the class. No reading quiz is dropped.

iv) **Exams:**

Both Midterm and Final Exams will be administered and submitted online on BBLearn. You can enter your answers directly on BBLearn, or write them on papers and take high-resolutions pictures, or turn them into PDFs, for submission. Please submit only .jpg, .png, or .pdf files.

Exams will consist of both qualitative and quantitative questions. Makeup exams are not given except with official excuses. You must provide documentation and arrange with me to take it at a different time before the exam. **Exams will be open-book/open-notes style, however you are NOT allowed to access search engines (and I will know because if you can google answers, I can google your answers too).** Any plagiarism will be 0 points for the entire Exam.

Below are the details of all assignments and assessments.

Homework Assignments

	Question 1		Question 2		Question 3	Points
Ch3 HW1	Solar irradiance	4	Magnitude and flux	6		10
Ch3 HW2	Blackbody curves	11	Raleigh-Jeans law	12	Wien's displacement law	5 28
Ch5&3.6 HW1	Electronic transitions	8	Series limits	6		14
Ch7 HW1	Mass, luminosity, and radius determination of Sirius A & B	17				17
Ch7 HW2	Mass determination of zeta the binary	10				10
Ch7 HW3	Eclipsing Binary Simulator	28				28
Ch8 HW1	Maxwell-Boltzmann distribution	13	Boltzmann Equation	14		27
Ch8 HW2	He I Partial ionization zone in a pure He atmosphere	15	Balmer absorption strongest in A-type stars at T-9900 K	6	Extra Credits (7pt): He II partial ionization zone in a pure He atmosphere	21
Ch9 HW1	Curve of growth and abundance of elements, Part II	20				20
*Plots required. *Coding required.						175

Activity Assignments

		Method	Group Size	Points
Ch3	#1: Stellar Properties	In-person	Large	10
	#2: Star Map	BBLearn	(Individual)	10
	#3: Parallax Exercise	BBLearn	(Individual)	10
	#4: Blackbody Radiation of You	BBLearn	(Individual)	10
Ch5&3.6	#5: Color-Color Diagram	Google Slides	Small	10
Ch7	#6: Mass of Spectroscopic Binaries	Google Slides	Small	10
	#7: Light Curves of Eclipsing Binaries	Google Slides	Small	10
Ch8	#8: Hydrogen Atom's Electron Orbitals	Google Slides	Large	10
	#9: Mini H-R Diagram	Google Slides	Large	15
Ch9	#10: Stellar Temperatures	BBLearn	(Individual)	10
	#11: Photon-Particle Interactions	Google Slides	Small	10
	#12: Curve of Growth & Abundance of Elements, Part I	Google Slides	Small	5
Ch15	#13: Modeling Stellar Interior, Part I	Google Slides	Small	10
	#14: Modeling Stellar Interior, Part II	Google Slides & Google Sheets	Small	10
	#15: Modeling Stellar Interior, Part III	Google Slides & Google Sheets	Small	10
				150

Reading Quiz Assignments

	Points
Ch3	10
Ch5&3.6	14
Ch7	13
Ch8	8
Ch9	15
	60

Brief Learning Guide

i) Be diligent, proactive, and ask questions.

Stellar astronomy is a very much ongoing research, especially when applying to extrasolar planet studies, and it is an excellent field to apply fundamental physics. The materials are not hard but require diligent learning and practice, which will in turn repay you with lots of fun and accomplishment. Many difficulties may rise simply due to not knowing some *jargons* (definitions, symbols, names etc). But as long as you are patient and willing to learn, you can be an excellent stellar astronomer as well!

ii) Think big and accept approximations.

One of the reasons that I love astronomy is because even though it is not as precise as physics, it turns physics into *beautiful objects* such as stars, galaxies, and even dark matter. Much of astronomy is empirical or based on observations, and observations can be limited due to technology or natural conditions. So even in stellar astronomy, one of the most well-studied fields in astronomy, our knowledge of stars can still be evolving. We also approximate many calculations and you have to accept that. Astronomy is not like physics or chemistry, or math, where we can find precise equations and rules to describe everything we see.

iii) Keep making progress and know where to find your resources.

The Universe is so big (like a puzzle) and there is no reason to believe that I know *everything*. I will do my best to guide you through stellar studies, and provide you ways to resources, but at times we may have to learn about new observations or theories together. Please feel free to share and participate, and do not worry about making mistakes. We all learn and advance from making mistakes.

Tentative Schedule

Week	Dates	Text	Topic
1-2	8/24 — 9/2	Ch3	Class introduction & The continuous spectrum of light
3-4	9/7 — 9/23	Ch5&3.6	The interaction of light and matter & The color index
5-7	9/28 — 10/14	Ch7.1-7.3	Binary systems & stellar parameters
	10/14 (Thu)	MIDTERM DUE: Ch 3, 5 & 7	
8-10	10/19 — 11/4	Ch8	The classification of stellar spectra
11-13	11/9 — 11/24 (No class on 11/11, 11/25)	Ch9	Stellar atmospheres
14-15	11/23 — 12/2	Ch 15 in R&P	Stellar Interior in Ryden & Peterson
16	12/9 (Thu)	FINAL EXAM DUE: Ch 8, 9 and 15 in R&P	

Respect for Diversity

It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you. I am NAU Safe Zone certified.

COVID-19 REQUIREMENTS AND INFORMATION

Additional information about the University's response to COVID-19 is available from the **Jacks are Back!** web page located at <https://nau.edu/jacks-are-back>.

University Policies

- **Academic Integrity Policy**

Simply two words— no tolerance. *All students* involved will receive zero points on that assignment or exam. If cheating/ plagiarism continue, you will receive an F in the class and the Dean's office will be notified.

- **Student Institutional Excuses Policy**

Also see the new [Faculty Notification Request form](#) if you must miss classes.