

# **AST 383D - Stellar Structure and Evolution**

## **Fall 2019 - Unique No. 46065**

**Meeting Times :** T/Th 11:00 — 12:15pm in PMA/RLM 15.216B

**Course Webpage:** <https://utexas.instructure.com/courses/1239633>

**Instructor: Prof. Keith Hawkins**

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### **Course Description:**

Whether exploring the farthest reaches of the cosmos or the very nature of the solar system, *stars are a fundamental building block of the universe*. This course covers the theoretical and observational nature of stars. More specifically, we will explore the basic physics needed for stellar astrophysics, the interior structure of stars and how they evolve over time. This introductory graduate-level course will be both touching on the theory of stellar structure and evolution while also exploring the observational and experimental nature of stars. Intermixed with lectures, our journey through the star this semester will feature techniques from an inquiry-based approach to learning, which include group activities and projects, peer-to-peer discussions, and written or oral presentations on current discoveries in stellar astrophysics as well as student presentations reviewing the course material.

## **Pre-reqs, Required Material, and Use of Electronics:**

### **Pre-requisites and Core Requirements:**

Suitable for all beginning and advanced graduate students in astronomy and physics. Otherwise consent of instructor is required.

**Course-Level Learning Objectives and Goals:** By the end of this course you should understand —

- the global properties of stars
- The underlying macro/micro-physics relevant for stars : the equations of state, nuclear reactions, energy transport, opacity, thermodynamics and statistical mechanics, virial theorem
- How to derive the equations necessary to model the internal structure of stars
- The physical processes of the formation *and* evolution of stars from birth to death and how it depends on mass
- How to examine the properties of simple stellar models & compare them with observations

**Texts and Materials:** As you will find, or already know that, courses, and the required textbooks, are expensive in 2019! To minimize cost to students, this course requires a textbook that can be obtained electronically from the PMA library for FREE. However print copies can be found online

- **REQUIRED:** “*Stellar Structure and Evolution*”, **2nd Edition**, Kippenhahn, Weigert, Weiss. Available at Coop or online for ~\$60. Please make sure to the 2nd edition!
- **OPTIONAL:** “*Stellar Interiors*”, 2nd Edition. Hansen, Kawaler, Trimble. You are free to use an earlier version of this text if you prefer. The text is completely optional for the course and is not required to succeed.

**Use of electronics:** Computers for note-taking is allowed. Other electronic devices can only be used for polling and attendance. Students using their electronics for non-class activities are a distraction to those around them. If I find your use of electronics a problem and a distraction to others, I will ask you to leave the classroom. Also, if you are distracted by non-academic use of electronics by a fellow student, you can ask them directly to stop or notify the instructor who will follow-up.

## **Class Structure:**

**Overview :** We will be covering three main topics this semester including

1. Preliminary Physics of Stellar Astrophysics

2. The Structure, Life, and Death of Stars
3. Applications of Stellar Astrophysics

**Attendance:** This class has a strong weight towards in-class participation. Therefore, attendance in this course is *highly recommend*. That said, graduate students often have varied responsibilities (conferences and observing). If you will miss class you must (a) let me know and (b) get all material from the class from another student. It is your responsibility to do both of these things.

**Class Website and email:** The class website is hosted on Canvas (<https://utexas.instructure.com/courses/1256650>) and should be checked regularly for updates and messages from me regarding exam review sessions, course materials, or special events. In addition to the class website, email is recognized as an official mode of university correspondence, so you are responsible for reading your email for university course-related information, and canvas-delivered announcements. Please check your email regularly and frequently and make sure you are set to receive notifications from Canvas as appropriate. When sending an email to us please put AST383D in the subject.

**Grading Components and Policies:** You will receive the grade you *earn* in this course. There likely will be no extra credit awarded in this class, so please be sure to put in your best effort throughout the semester to earn the grade you would like. Your final grade will be composed of the following elements:

Exams = 30% — Written Exam (10%) ; Oral Comprehensive final exam (20%)

Homework = 25%

Presentations & Participation = 25% (see below)

Quiz & Project = 20% (see below)

Here is more information on each of the grade components:

Exams (30%): There will be one closed-notes, closed-book midterm exams (10%) covering material discussed in class, as outlined in the class schedule. The *tentative (subject to change)* date for this exam is Oct. 22, 2019. There will be one *oral final exam whose date is not yet set*. The oral final is comprehensive (20%) and is modeled after the qualifying exam in order to prepare you for that.

Homework (25%): The due dates (and times) for homework will be posted to Canvas (though a rough guide can be found below) so please check the class website regularly! **Late homework policy** — *Each 24 hours past the deadline is reduction in 10% off the final grade of the assigned work. After 4 days post deadline, no work is accepted.* Each homework assignment is worth a different number of points depending on length and difficulty, and at the end of the semester those points are added together to form your overall homework grade. Group work and discussion is allowed (and encouraged) for homework assignments, but each student must be responsible for their own understanding of the material from each assignment and independently complete

the work. When computing the final grade, I will drop your lowest 1 (one) homework assignment.

*Class Presentations and Participation (25%):* In-class participation is a major component of your grade. You will carry out many of the in-class activities, peer-to-peer discussions and engage with the material over the semester. You are expected to participate in in-class discussions as these are critical for learning.

Students will engage twice a week in presentations. These types of presentations include:

1. *Oral Review on Tuesdays:* Every Tuesday of the semester students will sign up to present an oral review (in front of the class) of the previous weeks worth of material. This presentation can be whatever medium or form the presenters would like but must be ~10-15 minutes in length and adequately review all material covered in that week. These reviews will then be used to generate questions for the exams.
2. *Journal Club on Thursdays:* Every Thursday of the semester students will sign up to present the background, findings, and weak spots of an original peer-reviewed article on a pre-approved topic of stellar astrophysics. Papers can be found on NASA Astrophysical Data System (NASA ADS) or the arXiv. Students are also encouraged to consider how they would improve or expand on the paper.

The rota for these two signup can be found at <https://docs.google.com/spreadsheets/d/1J0k-HUL3vvftSmtOS8byaXN457ntGBS-lgt6oczczl0/edit?usp=sharing>

Rubrics for the grading of these presentations can be found on Canvas!

\*Depending on enrollment each student should expect to do 2-3 of each of these.

*Projects / Quiz: (20%)* — You will be responsible for the completion of a numerical stellar astrophysics project using the MESA stellar structure and evolution code, which can be found at, <http://mesa.sourceforge.net/index.html>. The details of this project will be announced a few weeks into the class with an accompany grading rubric.

***This class will not be graded on a curve.*** Your grade is calculated to the nearest 1/10th of a percentage point. The average percentage in each of the above grade components will be weighted by the indicated percentage to derive the final course grade, assigned as follows:

93.0 — 100% = A	80.00 — 82.9% = B-	67.00 — 69.9% = D+
90.0 — 92.99% = A-	77.00 — 79.9% = C+	63.00 — 66.9% = D
87.0 — 89.9% = B+	73.00 — 76.9% = C	60.00 — 62.9% = D-
83.0 — 86.9% = B	70.00 — 72.9% = C-	0 — 59.9% = F

If you have a question about your grade feel free to meet with Prof. Hawkins. If you have a request to appeal/change grade, please send Prof. Hawkins an email with the scan of the attached assignment and *at least 2-paragraph (i.e. 500 word) justification* on why you believe your grade should be changed.

## **Other University / Class Policies**

**Accommodations for disabilities and/or family responsibilities:** If you have any kind of disability, whether apparent or non-apparent, learning, emotional, physical, or cognitive, and you need some accommodations or alternatives to lectures, assignments, or exams, please feel free to contact me to discuss reasonable accommodations for your access needs. Students with disabilities should also request appropriate accommodations from the Division of Diversity and Community Engagement, and from UT's Services for Students with Disabilities. The official wording provided by the university is: The University of Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-6441 TTY or Division of Diversity and Community Engagement, Services for Students with Disabilities, 512-471-6259, [www.utexas.edu/diversity/ddce/ssd](http://www.utexas.edu/diversity/ddce/ssd).

**Regarding harassment/assault:** Harassment of any sort will not be tolerated in this classroom or related workspaces. Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights violations subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, etc. If you or someone you know has been harassed or assaulted, you can find the appropriate resources through the University Title IX Coordinator (512-232-3992), UT Austin Campus Police (512-471-4441), the Student Ombuds Services (which can provide *confidential* advice, resources and help; 512-471-3825), and the UT Counseling and Mental Health Center (512-471-3515). Remember as a Professor, I am a mandatory reporter.

**Academic Dishonesty:** The minimum penalty for cheating — in any way whatsoever — is receiving a zero on the assignment on which you cheated. I reserve the right to seek a penalty I deem appropriate for the given case of academic dishonesty, including failing the class and being reported to Student Judicial Services (SJS). In this class, in addition to all the traditional types of cheating (looking at someone else's answer, utilizing "cheat sheets" of any form or fashion either paper or digitized, getting an advance copy of an assessment). If the academic honesty is sufficiently serious, I will proceed by filing a formal report to the Judicial Services in the Dean of Students Office as is policy. Judicial Services would decide the final penalty after a hearing on the matter. For more information, read in the General Information Catalog about scholastic dishonesty (i.e. cheating). See more information at <https://astronomy.utexas.edu/academics/graduate-program/policy-on-academic-honesty>.

**Diversity & Inclusion** : Astronomy belongs to all people, independent of race, religion, gender, gender identity, gender expression, nationality, citizenship status, or sexual orientation. Incidents of discrimination, assault, harassment, threats, intimidation, profiling, or coercion based on membership or perceived membership will not be tolerated! The University of Texas President's statement of community values can be found here: <http://equity.utexas.edu/presidents-statement/>. If you notice an incident that causes concern, please contact the Professor and the Campus Climate Response Team (<http://diversity.utexas.edu/ccrt>).

**Make-up/Guest Lecture Classes:** I am a professional Astronomer. In addition to my obligations to you and the other students in this and other courses, I have responsibilities to remain professionally competent through individual research. As a consequence, I may occasionally need to be away conducting research or attending a scientific meeting. Usually another faculty member will conduct the class when the regular instructor is absent. I will be attending representing UT Austin at a professional meeting on Aug 29 2019, Oct 3 2019, Oct 22 2019 and Nov. 19, 2019. Make-up classes or Guest lectures will be scheduled for these.

**Religious Holidays:** A student absent from an examination for the observance of religious holidays are permitted to make up missed work if notice is given at least fourteen (14) days in advances of an absence.

### Approximate Class Schedule — Fall 2019

**Class Material and Schedule:** Below is the *VERY ROUGH*(!!!!!!!!!!!!!!) course schedule and material we will cover on those days. **This is subject to change.** All homework are due by the beginning of the class period on the date noted in the schedule.

*KWW = Kippenhan, Weigert, Weiss*

*HKT = Hansen, Kawaler, Trimble*

<b>Date</b>	<b>Lecture Topic</b>	<b>Pre-Class Reading</b>	<b>Homework (not including journal club reading / review prep)</b>
Aug 29	No class — Syllabus Day		Read Chap 1-2 (KWW); Syllabus

Sep 3	Introduction to Stellar Astrophysics and why it is important	All Chapter 1-2 of KWW	
Sep 5	Stellar Astrophysics Primer : Through the HRD	Chap 2 of HKT & <a href="https://people.umass.edu/wqd/astro643/evol.pdf">https://people.umass.edu/wqd/astro643/evol.pdf</a>	
Sep 10	Conservation Principals and Timescales of stellar theory	Chapter 2 KWW	
Sep 12	The Virial Theorem and its applications	Chapter 3 of KWW	
Sep 17	Review of Thermodynamics	Chapter 4 KWW	
Sep 19	Energy Transport by radiation and conduction	Chapter 5 KWW	
Sep 24	Energy Transport by convection	Chapter 6-8 KWW	Homework #1 Due
Sep 26	Equations of State of Matter	Chapter 10-11 KWW	
Oct 1	Boundary Conditions	Chapter 12-13 KWW	Q
Oct 3	Work on Stellar modeling Projects - Build a Star	Chapter 14- 16 KWW	
Oct 8	Energy Sources and Sinks in Stars	MESA Projects Guidelines, Chapter 17-18 KWW	
Oct 10	Simple Model of Stars I	Chapter 19-21 KWW	
Oct 15	Simple Model of Stars II	Chapter 19-21 KWW	Homework #2 Due
Oct 17	Numerical Models	Chapter 19-21; Chapter 12 KWW	
<b>Oct 22</b>	<b>Midterm</b>		
Oct 24	Star Formation & Hayashi Track	Chapter 24,26-29 KWW	
Oct 29	Main Sequence	Chapter 30 KWW	
Oct 31	RGB stars	Chapter 31-33	

Nov 5	AGB Stars	Chapter 34-35	
Nov 7	Low Mass Death	Chapter 36-37	
Nov 12	High Mass Death	Chapters 38-39	Homework #3 Due
Nov 14	Pulsating stars & astero-seismology I	Chapter 41	
Nov 19	Work on MESA Projects		No class
Nov 21	Pulsating stars & astero-seismology I	Chapter 42	
Nov 26	Stellar rotation and ages of stars	Chapter 43	
Nov 28	Thanksgiving No Class		
Dec 3	Presentation of Projects I		
Dec 5	Presentation of Projects II + Final Exam Review + Application of Stellar Astrophysics in the Gaia Era		Homework #4 Due