Astronomy 435: Stellar Structure and Evolution

Spring 2022 (3 credits) TuTh 2:50-4:05pm Webster 11
Prerequisites: MATH 172 or 182; PHYSICS 202 or 206

Instructor: Dr. Matthew Duez

Office Location:	Webster 947E
Phone:	(509) 335-2396
Email:	m.duez@wsu.edu
Office hours:	Monday 3-4:30pm

Textbooks

Required: *An Introduction to Modern Astrophysics* by Carroll and Ostlie

Student Learning Outcomes

The goal of this class is to teach students the concepts and techniques of stellar modeling. Relevant physics includes spectroscopy, gravitation, hydrostatics, radiation transport, and nuclear reactions. Relevant techniques include classification of stars (the MK system), methods of inferring stellar properties, and numerical modeling of stellar equilibria.

By the end of the class, students should

- understand the key physics of stellar modeling: gravitation, hydrostatics, radiation transport, convection, and nuclear reactions
- understand how stellar properties are inferred
- become familiar with the spectral classification of stars
- become comfortable with computational modeling in python
- numerically construct models of main sequence stars

Grade Breakdown

Homeworks:	40%
Final Notebook	10%
Homework presentations	10%
Final presentation	10%
Exam 1:	15%
Exam 2:	15%

Homework, homework presentations, and final notebook

There will be 8 homework assignments, roughly one per week. Homework will help guide lectures, so we will spend some time in class discussing assignments before they are due. Stellar modeling is done numerically, so homework will have a significant computational component.

Students will have online access to a Google Drive for this class. Each homework will be given as CoLaboratory notebook (a Jupyter notebook designed to be run on Google's cloud, meaning you can work from any machine with a web browser). Each student will make their own private copy of the homework, to be used to perform calculations, design algorithms, and write up results. Students can modify their assignment notebooks until the homework is due. To "turn in" the homework, all that is necessary is to share the file with the instructor before the beginning of class on the due date. At the beginning of class on the due day, a group of two students will present the solutions to the class. It is strongly recommended that the presenting students come to my office sometime before lecture (my office hour that week or by appointment) to check their work with me. Homework solution presentations are a non-negligible component of students' grades, as indicated above. After the presentation, attending students will be allowed to write a supplemental page to their homework listing things they think should be corrected in their original assignment. Depending on the quality of the supplement, students may recover up to 50% of the points they would have missed on the original assignment.

The numerical portion of the homework has a cumulative component. Over several weeks, students will build modules that must work together for the ultimate goal of generating the main sequence stellar model of a star of given mass and composition. Students will submit their completed modeling code at the end of the semester. If a physics module is not working when the corresponding homework is due, students are encouraged to continue debugging it because it will be needed again for the final notebook submission. (If students get their code working as it is due, the final notebook submission will be little work.)

Exams

There will be two tests which will be a combination of short essays and order of magnitude problem solving. Prior to each test, I will provide a list of practice questions, and your actual test will consist of variations on some subset of these.

Final presentation

At the end of the semester, each student group will give a presentation on some topic of its choosing (approved by the instructor) on planetary astronomy.

Grade distribution

Below is a rough guide to how numerical grades will correspond to letter grades. I won't push the cutoffs up, but may push them a little bit down.

A	88-100%
B	75-87
C	63-74
D	50-62
F	< 50

Academic Integrity

Students may discuss and work together on assignments, but all submitted work must be original and individual. Academic dishonesty, including all forms of cheating, plagiarism, and fabrication, is prohibited as stated in the WSU Handbook. (See http://conduct.wsu.edu/.)

WSU Disability Statement

Reasonable accommodations are available for students with a documented disability. Please notify me the first week of class of any accommodations needed. Late notifications may cause requested accommodations to be unavailable. All accommodations must be approved through Disability Resource Center (DRC), Administration Annex 205, 335-1566.

WSU Safety

For WSU's general safety statements, see http://safetyplan.wsu.edu.
For current safety alerts, see http://alert.wsu.edu.
For advice on dealing with emergencies, see http://oem.wsu.edu/emergencies.

Course Outline

Material:	magnitudes; blackbody laws
Homework 1:	chapter 3 exercises; code: loops and plotting
Material:	spectral lines; Saha equation
Homework 2:	spectral classification of stars
Material:	Hertzprung-Russell diagram; radiation measures
Homework 3:	chapter 8 exercises; code: conditionals
Material:	opacity sources; random walk
Homework 4:	chapter 9 exercises; code: opacity module
Material:	radiation transfer
Homework 5:	chapter 9 exercises; code: stellar atmosphere integrated opacity
Midterm	
Material:	hydrostatic equilibrium; polytropes; stellar timescales
Homework 6:	chapter 10 exercises; code: Lane-Emden ODE integration
Material:	nuclear reactions; energy transport
Homework 7:	chapter 10 exercises; code: radiative stars
Material:	energy transport
Homework 8:	chapter 10 exercises; code: main sequence star model
Material:	boundary value ODE solution by shooting methods

Student presentations on planetary astronomy
Final notebook: generates zero age main sequence model of a specified mass and composition
Final Exam