# Syllabus - ASTR 565
# Stellar Structure and Evolution
# Fall 2015

Dr. Jason Jackiewicz
jasonj@nmsu.edu · 646.1699

Associate Professor of Astronomy
New Mexico State University

## 1 Overview

This course will survey the physics of the interiors of stars and their evolution. Emphasis will be on dynamical processes, equations of stellar structure and evolution, and their approximate solutions. This is one of the most fundamental topics in astronomy because so much of our universe has to do with stars.

The Sun is the star that provides the conditions for life on Earth. It is also the nearest stellar object and can be studied in a great amount of detail. Not only can we learn about the Sun itself, but we can use this information to study other stars and stellar systems. It is the most important astronomical object for many scientists, and will be used in some sense as a reference and testbed for other stars.

Insights into the physics and processes occurring inside stars will be obtained through numerical modeling using a state-of-the-art code called MESA. This will be a tool for you to help answer questions about stellar astrophysics, and provide a way to visualize the richness of this complicated field. It might also help you in future research pursuits.

Some of the topics on which we will concentrate will be explored through group work in class. Students are encouraged to ask questions, including those directed to other students. Developing problem solving and critical thinking skills (see below) will be a high priority along with useful physics and mathematical training. Hopefully, these skills will help you on your future graduate school exams.

## 2 What to expect to take away from this course

This course is designed for you - the student - to learn. One can characterize this by explicitly listing very broad and general **learning goals** and then more specific **learning outcomes**. Everything we do will be directed towards these goals and outcomes.

### Learning goals

In two or three years from now, after this course has long been forgotten, I want the following items to be the legacy of what we did this semester. You will

1. have developed problem-solving and critical thinking skills that will help you in whatever research direction you choose,

2. have improved your ability to work productively with others and to convey your ideas clearly and succinctly,
3. possess a broad understanding of stellar astronomy and its relation to astronomy as a whole,
4. appreciate the Sun as an important and very useful astronomical object and the target of current research,
5. have improved your basic and some higher-level mathematical and analytical skills.

### Learning outcomes

Based on the above goals, here we specify outcomes (or objectives) connected to the goals.

- **Recognize** and **identify** the main concepts in a research article about stellar interiors and/or evolution when it appears in journals such as *Nature* and *Science*. Also, be able to **discuss** intelligently several of the monthly articles in a more specific journal like *Astrophysical Journal*.
- **Investigate**, **compare**, and **contrast** the properties of stars across the H-R diagram.
- Be able to **execute** a stellar evolution code and **present** the results in a graphical to answer questions.
- **Give examples** and **illustrate** how stars of different mass evolve in time.
- **Set up** and **organize** all of the relevant equations of state, motion, equilibrium, conservation, as well as any constitutive relations that go into static and dynamic stellar models. This can begin with looking them up in a textbook. **Propose** a method or scheme whereby these equations are solved to constitute a full model.

### Main topics

The broad science topics or "units" that we will focus on are (in no particular order):

equation of state· nuclear energy generation · hydrostatic equilibrium · polytropes · radiation and opacities · convection · stellar timescales · mass-luminosity relations · the main sequence · post main-sequence evolution.

## 3 Assessment

You will be graded for the course based primarily on the learning goals and outcomes outlined above. Some of your assignments will be solving in-class group problems. There will also be several homework assignments that will be computational in nature. Some short quizzes will take place in addition to a final exam. An important thing is class participation and your activity asking and answering questions.

## 4 Grading

We will have the following grading distribution and final grades will use the ± system:

| | |
|---|---|
| Class participation | 10% |
| Computational projects | 50% |
| Short homeworks and quizzes | 25% |
| Final Exam | 15% |

# 5 Other details

## Prerequisites

Hopefully you will have a relatively strong background in calculus, linear algebra, and plotting data. However, any necessary deficiencies will be addressed in the course. You will also need access to a computer, preferably on one of our servers.

## Materials

There will be no official textbook: required materials will be given as needed, along with any suggested readings below. The NMSU Canvas system will be used mostly for grade recording and to redirect you to the main course website that you should check very regularly. It is http://astronomy.nmsu.edu/jasonj/565/.

Recommended texts are:

- *Stellar Structure and Evolution*. Kippenhahn and Weigert (1990).
- *Introduction to Stellar Physics, Volume 3*. Böhm-Vitense (1992).
- *Structure and Evolution of the Stars*. Schwarzschild (1958).
- *Stellar Evolution*. Harpaz (1994).
- *Stellar Interiors*. Hansen and Kawaler (1994).
- *Principles of Stellar Evolution and Nucleosynthesis*. Clayton (1983).
- *An Introduction to the Theory of Stellar Structure and Evolution*. Prialnik (2000).

## Office hours

My office is room 106 in the Astronomy building. You can come by any time the door is open!

## Policies

Plagiarism is using another person's work without acknowledgment, making it appear to be one's own. Any ideas, words, pictures, or other source must be acknowledged in a citation that gives credit to the source. This is true no mater where the material comes from, including the internet, other student's work, unpublished materials, or oral sources. Intentional and unintentional instances of plagiarism are considered instances of academic misconduct. It is the responsibility of the student submitting the work in question to know, understand, and comply with this policy.

Check the NMSU student code of conduct manual for more information[1]. We will adhere to those policies in this course. In short, **always cite** work done by others that you borrow. The NMSU Library has more information and help on how to avoid plagiarism[2].

Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act (ADA) cover issues relating to disability and accommodations. If a student has questions or needs an accommodation in the classroom (all medical information is treated confidentially), contact: Trudy Luken, Student Accessibility Services (SAS) - Corbett Center, Rm. 208, Phone: 646.6840. E-mail: sas "at" nmsu.edu. Website[3].

NMSU policy prohibits discrimination on the basis of age, ancestry, color, disability, gender identity, genetic information, national origin, race, religion, retaliation, serious medical condition, sex, sexual orientation,

[1] http://deanofstudents.nmsu.edu/student-handbook/
[2] http://lib.nmsu.edu/plagiarism/
[3] http://www.nmsu.edu/~ssd/

spousal affiliation and protected veterans status. Furthermore, Title IX prohibits sex discrimination to include sexual misconduct, sexual violence, sexual harassment and retaliation. For more information on discrimination issues, Title IX or NMSU's complaint process contact: Gerard Nevarez or Agustin Diaz, Office of Institutional Equity (OIE) - O'Loughlin House, 1130 University Ave. Phone: 646.3635. E-mail: equity "at" nmsu.edu. Website[4].

[4] http://www.nmsu.edu/~eeo/