# Stellar Astrophysics
## ASTR 404 Fall 2014

**Course Meeting**
Monday/Wednesday/Friday 1:00-1:50 pm
Astronomy Classroom

**Instructor**
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**Course Description**
Stars are the building blocks of the Universe. We will explore the underlying physics of stars, figuring out why they exist, how they work, how, when, and why the evolve, and what they will eventually become. Primary topics will include the structure of self-gravitating objects, energy transport in stars, nuclear fusion in stars, stellar evolution, and the birth of compact objects. At the end of this course, you will have an understanding of stellar structure and evolution.

**Course Requirements**
This is an upper-division course in astronomy. All introductory astronomy, physics, and mathematics courses must be fulfilled. The most advanced mathematics will be (simple) differential equations, but one must be familiar with them. Similarly, one must be familiar with how light, blackbody radiation, gravity, and nuclear reactions work. Having experience in other upper-division astronomy course will be helpful. Topics building on knowledge from upper-division quantum mechanics, thermodynamics, electromagnetism, classical mechanics, and statistical mechanics will all be covered in this course. Although I will review much of this material (briefly), it is highly recommended that you have already taken these courses or are currently doing so.

We will be using the MESA stellar evolution software package. Although you do not need to know how to program to use it, you must be familiar with a UNIX environment, know how to run programs from the command line, edit text files, etc. MESA does *not* run on Windows, so you will need to have a Mac, a linux machine (or partition), or an account in the astronomy department.
Download MESA at `http:mesa.sourceforge.net`.

**Texts**
*The Physics of Stars* – Phillips – ISBN:978-0471987987
*An Introduction to Modern Astrophysics* – Carroll & Ostlie – ISBN:978-0805304022

**Grading**
40% – roughly 7 homeworks
15% – first midterm exam (Sept. 18)
15% – second midterm exam (Oct. 23)
30% – final exam (Dec. 9 + take home)

The homework will be due on Fridays *at the beginning of class.* No late homework will be accepted.

**Tentative Syllabus (subject to change)**
**Week 1**:

Overview of stars, MESA, and plotting. Most of this can be found in introductory textbooks, but C&O is a particularly good resource. Zeroth homework due.

**Week 2**:

Read all of Phillips Chapter 1. Don't stress about the derivations; just look over the material to get an idea of the level of the course. But focus on Phillips 1.2 and 1.1 (in that order!).

Introduction to stars, basics. The H-R diagram. Gravitational free fall. Hydrostatic equilibrium. Virial theorem. First homework due.

**Week 3**:

Phillips 1.1, 2.1, and 2.3. C&O 10.1.

Hydrostatic equilibrium. Virial theorem. Second homework due.

**Week 4**:

Phillips 1.4 (excluding the fusion section) and 3.1. C&O 10.4.

Energy transport by radiation/conduction. Energy transport by convection. First Midterm.

**Week 5**:

Phillips 3.2 and 3.3. But Phillips is a little lacking here. Also see C&O 10.4.

Energy transport by convection. Polytropes. Fully convective stars. The Hayashi line.

**Week 6**:

Phillips 1.3 (excluding "conditions for stardom"). C&O 12.2 and 12.3.

Star formation and pre-main sequence evolution. Third homework due.

**Week 7**:

Phillips 1.3 and 1.4 (the fusion section). C&O 12.3 and 10.3.

Star formation and pre-main sequence evolution. Kelvin-Helmholz contraction. Energy generation in stars: the p-p chain.

**Week 8**:

Phillips 1.4, 1.5, 4.1, 4.2. C&O 10.3 and 10.6.

Energy generation in stars: the p-p chain. Energy generation in stars: the CNO cycle. Origin of the main sequence. Fourth homework due.

**Week 9**:

Phillips 5.1 on equations of stellar structure. Also 2.1 and 2.2 on ideal classical/degenerate gases and 5.4 on the minimum and maximum masses of stars. C&O 8.1, 8.2, 10.6, and 13.1.

Origin of the main sequence. Spectral types. Second Midterm

**Week 10**:

Phillips 2.4 and 2.5. C&O 13.1 and 13.2.

Boltzmann and Saha equations. Evolution of Low-mass Stars (red giants, AGBs, mass loss, He fusion).

**Week 11**:

Phillips 4.3 on He fusion. C&O 13.2.

Evolution of Low-mass Stars (red giants, AGBs, mass loss, He fusion). Fifth homework due.

**Week 12**:

Phillips 6.1 and 3.4. C&O 15.2, 15.3, 15.4, and 15.5. The supernova parts of 17.4.

White dwarfs. Type Ia supernovae.

**Week 13**:

Phillips 3.4, 2.6, and 4.4. C&O 13.3.

Type Ia supernovae. Evolution of massive stars. Sixth homework due.

**Week 14**:

Thanksgiving break.

**Week 15**:

Phillips 6.3 and 6.4. C&O 15.6, 16.1, and 16.3.

Core-collapse supernovae. Neutron stars. Black holes. Seventh homework due.

**Week 16**:

Summary. In-class final.

Please read the following information. You are responsible for knowing it. This course will follow all policies in the Student Code (http://www.admin.uiuc.edu/policy/code).

**Responsibilities**: You are responsible for showing up to class, participating in lecture (in a constructive manner), reading your email, reading the assigned material, handing your homework in on time, and taking the exams *at the specified times*. If something comes up which may prevent you from fulfilling your responsibilities, notify the Instructor immediately.

**Personal Issues**: To insure that concerns are properly addressed from the beginning, students who require reasonable accommodations to participate in this class are asked to see the instructor as soon as possible. All accommodations will follow the procedures as stated in sections 1-107 and 1-110 of the Student Code.

**Academic Integrity**: Any instance of academic dishonesty (including cheating and plagiarism) will result in a grade of 0 for that component and be documented in the student's academic file. This includes copying written material from the Internet without proper attribution. Please refer to sections 1-401 to 1-406 of the Student Code.

For this class in particular, students must run the MESA simulations (including generating the initialization files) and plot the results separately. You should *never* copy work done by another student.