Physics 223: Stellar Structure

Spring 2016

Course Webpage:  http://pono.ucsd.edu/~adam/teaching/phys223

Instructor:  Prof. Adam Burgasser
340 SERF, x26958
aburgasser@ucsd.edu
office hours: We 3p-4p or by appt.

Course Manager:  Ms. Patti Hey
plhey@physics.ucsd.edu

Lecture Schedule:  Lecture: TuTh 12:30-1:50pm in 383 SERF
Workshop: W 2:30-3:50pm in 329 SERF
Lecture Make-up: F 2:30-3:50pm in 383 SERF

Textbooks:
  Hansen, Kawaler & Trimble, Stellar Interiors, 2nd ed.
  Kippenhahn & Weigert, Stellar Structure and Evolution
  Clayton, Principles of Stellar Evolution and Nucleosynthesis
  Erika Böhm-Vitense, Introduction to Stellar Astrophysics: Volume 3

Course Grading
Homeworks (30%): 4 assignments due @ 5pm on even Fridays

In-class Article Discussion (10%): Each student will lead discussion on one
  of the primary article references in class and write up a short
  (<1 page) review

Course Project (50%): An in-depth study of a specific topic related to the
  course, includes (1) a mid-term proposal, (2) paper and (3)
  oral presentation

Participation (10%): Based on participation in class discussions
# Course Syllabus (subject to change)

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Topics</th>
<th>Deadlines/Workshops</th>
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<tbody>
<tr>
<td>0-1</td>
<td>Introduction: star properties, cosmological context, HR Diagram, stellar structure eqns, virial theorem</td>
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<tr>
<td>1-2</td>
<td>Star formation, Jean's criteria, stellar mass and luminosity functions</td>
<td>Wk 2: MESA HW 1 (due 10/7)</td>
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<tr>
<td>3-4</td>
<td>Equations of state, distribution functions, ideal and degenerate gases, composition, polytrope models</td>
<td>Wk 3: Python Wk 4: Monte Carlo methods</td>
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<tr>
<td>4-5</td>
<td>Stellar energy generation, nucleosynthesis, reaction rates, pp &amp; CNO chains, triple alpha rxn</td>
<td>HW 2 (due 10/21) Project Proposal (due 10/28)</td>
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<tr>
<td>6-7</td>
<td>Stellar atmospheres, opacity, radiative transfer, line profiles, spectroscopy spectral classification</td>
<td>HW 3 (due 11/4) Wk 7: Literature Research</td>
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<tr>
<td>7</td>
<td>The Sun: helioseismology, neutrino problem, solar flares &amp; magnetosphere</td>
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<tr>
<td>8</td>
<td>Low &amp; high-mass stars: hydrogen-burning limit, eddington limit, multiplicity, rotation</td>
<td>HW 4 (due 11/18)</td>
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<tr>
<td>9-10</td>
<td>Stellar evolution, pulsation, stellar death, supernovae, degenerate remnants</td>
<td>Wk 8: Scientific Writing Wk 9: Effective Presentations Project Writeup (due 11/28) &amp; Presentation (due 12/2)</td>
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<td>Finals</td>
<td><strong>Project presentations</strong></td>
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**COURSE INFORMATION**

Physics 223 is a graduate-level astrophysics course on stellar interiors and structure. The goal of the course is to familiarize you with the physical processes and equations underlying the formation, structure, energy generation and evolution of normal stars. The topics include:

1. Fundamental properties of stars and cosmological context;
2. Star & planet formation
3. Equations of stellar structure & polytrope models;
4. Properties of gas, plasma, degenerate and “photonic” states;
5. Energy generation and nucleosynthesis;
6. Energy transport via radiation, conduction and convection;
7. Pre-Main Sequence, Main Sequence and Post-Main Sequence evolution
8. Degenerate stars (brown dwarfs, white dwarfs, neutron stars)

Depending on time, we will also touch on

9. The Sun as a star;
10. Binary star systems;
11. Stellar kinematics;
12. Stellar magnetic activity.

In addition, this course aims to provide training in practical skills important for success in graduate study and astrophysical research in general. Assignments will therefore include computational problems (Python recommended but not required), use of community software such as astropy and MESA, literature research, written assignments using LaTeX, and oral presentations. All students will be expected to present at least one journal article review in class. An optional weekly workshop session will be scheduled to provide training in these core skills.

**Prerequisites:** graduate standing or Physics 160 (exceptions will be considered). You should also be familiar with and be able to use basic computational techniques (e.g., numerical integration) and know at least one programming languages (Fortran, C, Python, IDL), which will be used for the homework assignments and possibly your projects.

**ASSIGNMENTS AND GRADING**

**NOTE:** Grade breakdowns will be determined by consensus during our
first class meeting.

**Homework** constitutes 30% of your grade. There will be 4 homework assignments worth 7.5% each. Assignments will be posted on the course webpage. Problems will include a mix of analytical and numerical problems. Assignments will be due on Friday at 5pm of even weeks (2, 4, 6, 8). Late assignments will be accepted but grade deductions are as follows:

- 3 business days EARLY: +10% bonus
- On time: full credit
- 1 business day: -25% deduction
- 3 business days: -50% deduction
- 1 week: -75% deduction
- More than 1 week late: no credit

You are encouraged to work together on homework, but the work you hand in must be your own. You may not use a prior year’s solutions, online solution or solutions from the textbooks. Anyone suspected of copying solutions is in violation of UCSD’s integrity policy, will receive a failing grade, and will be referred to the Office of Academic Integrity.

**Leading discussion of a paper** during lecture constitutes 10% of your grade. Readings will be drawn from primary sources and review papers, and will drive part of the class discussion. To encourage development of your skills in using primary sources, each student will lead one discussion during the quarter. This will include: (1) preparing a brief (5-min) summary of the paper’s salient points and (2) leading a 10-min discussion with the class, with supporting background. See the website for the discussion rubric. You will also prepare a short (< 1 page) report summarizing the main points of the review.

**The term project** constitutes 50% of your grade. The project can be on any topic clearly relevant to the course, with preference for a specific result from at least one primary source, rather than a general review. I will have a set of recent primary references to choose from, or you may choose your own primary reference.

A completed project consists of 3 parts:

1. A **proposal** (10%) describing the project topic, and outline of the paper and a list of references, which will be due at the end of Week
5 (Friday, October 28th). The proposal must be prepared using LaTeX with the provided style file.

2. A project paper (25%) 10-15 pages, including figures and references, due at the end of Week 10 (Friday December 2\textsuperscript{nd}). The paper must be prepared using LaTeX with the AASTex style file

3. A 10-minute presentation (15%) made during Finals Week.

Term projects must be done on your own. Plagiarism rules will be strictly enforced. \textit{Copying any portion of your paper or presentation from anyone or any source is not allowed, with the exception of short passages that should be explicitly quoted and properly attributed.}

Participation will be assessed by the instructor based on participation in class discussions.

Here is a rough breakdown of letter grades (plus and minus grades will be awarded within these ranges). Remember that a “pass” grade for graduate courses requires a C or better.

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>% Required</th>
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<tr>
<td>A</td>
<td>\geq 85</td>
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<tr>
<td>B</td>
<td>70-85</td>
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<tr>
<td>C</td>
<td>55-70</td>
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<tr>
<td>F</td>
<td>&lt; 55</td>
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Grade appeals are allowed but must be emailed to Prof. Burgasser within one week of receiving that assignment’s grade.

Scheduling conflicts due to athletic/artistic performance or research events (talks, meetings, etc.) must be reported at least one week in advance. Homework and projects must be turned in before the conflict.

Medical excuses must be accompanied by a physician’s note.

\textbf{ADDITIONAL COURSE DETAILS}

\textbf{Add/Drop:}
Use WebReg to add/change/drop, drop from waitlists. If you have any problems using WebReg, contact Sharmila Poddar (spoddar@physics.ucsd.edu) in 2561 Mayer Hall Annex.

\textbf{Equity and Inclusion:}
UC San Diego considers the diversity of its students, faculty, and staff to
be a strength, and critical to its educational mission. It expects every member of the university community to contribute to an inclusive and respectful culture for all in its classrooms, work environments, and at campus events. Dimensions of diversity can include sex, race, age, national origin, ethnicity, gender identity and expression, intellectual and physical ability, sexual orientation, income, faith and non-faith perspectives, socio-economic class, political ideology, education, primary language, family status, military experience, cognitive style, and communication style. The individual intersection of these backgrounds and characteristics are and must be valued in our community.

Title IX prohibits sex discrimination, including sexual misconduct, sexual violence, sexual harassment, and retaliation. If you or someone you know has been harassed or assaulted, you can find resources available to support the victim, including confidential resources, advocacy, and information concerning reporting options, at the Sexual Assault Resource Center (https://students.ucsd.edu/sponsor/sarc/)

If there are aspects of the design, instruction, and/or experiences within this course that create barriers to your inclusion in the course or accurate assessment of your achievement, please notify me as soon as possible so that we may remedy these.

Disabilities:
The UCSD Office for Students with Disabilities (OSD) is available to work with students with disabilities to facilitate accommodations due to disabilities. These include adaptive software and technologies, captioning and interpreters, AS and peer notetakers and exam modifications. Students requesting these services must obtain and submit an Authorization for Accommodation (AFA) letter to the instructor no earlier than 3 working days prior to receiving accommodations. For more information, see the OSD website (http://disabilities.ucsd.edu). I will also consider accommodations without formal OSD approval, on a case-by-case basis. Please do not hesitate to ask if you feel you need accommodation.

Academic Integrity:
Please read “UC Policy on Integrity of Scholarship” in the UCSD General Catalog. Any students caught cheating or plagiarizing will be reported to the Office of Academic Integrity and may be expelled from the course.