AST 304, Fall 2016

Stars

Syllabus

This one-semester undergraduate course covers the physics governing the structure and evolution of stars and star-like objects.

Course goals

Stars are macroscopic objects, and describing their behavior requires weaving many separate topics in physics into a coherent narrative, often via numerical simulation. In this course, you will also learn astronomical nomenclature and practical skills in numerical calculation and working collaboratively. These skills apply not only to modeling astronomical phenomena, but also to many "real-world" phenomena, such as weather and climate.

Instructors

Professor Edward Brown

BPS 3266
884–5620
browned@msu.edu
http://www.pa.msu.edu/~ebrown
https://github.com/nworbde
http://twitter.com/nworbde

Office hours: TTh 11:30–12:30, T 2:00–3:00; or by appointment.

Undergraduate Learning Assistant Claire Kopenhafer

1248 BPS
kopenhaf@msu.edu

Office hours: M 2:00–3:00

Lecture times and location

TTh 12:40–2:00 in 1420 BPS

Click on links in gold-colored text to go to online material.

Textbook and course materials

Required

1. LeBlanc, F. 2010, *An Introduction to Stellar Astrophysics* (Wiley & Sons, Ltd.). Electronic versions of this book are available from Amazon, Barnes & Noble, and Google Play.

2. An up-to-date version of Anaconda Python.

3. An up-to-date installation of `git`. Mac and Linux users have this already as part of their OS. Windows users should download and install git for windows.

4. An account with the online CATME assessment tool for group projects. Instructions on how to access this will be sent to your MSU email account during the second week of the course.

Supplemental

1. Barbara Ryden and Bradley M. Peterson. *Foundations of Astrophysics*. Addison-Wesley, 2010.

2. Notes on stellar physics (at a graduate level) are available at this link or from the Open Astrophysics Bookshelf.

3. Allen Downey. *Think Python*. Green Tea Press, 2013. A free download is available from this link.

4. I will make use of the open-source stellar evolution code `MESA`; if you want to explore `MESA` for yourself, you will find installation instructions and tutorials on its homepage and user-contributed materials at the `MESA` user forum.

Additional material, as well as homework assignments and projects, will be posted on D2L.

Homework and in-class worksheets

Homework sets are assigned weekly and are due Thursdays at the start of lecture. We will assign one of 4 grades: ⊘ (not done), − (below expectations), ✔ (meets expectations), + (exceeds expectations). Note that a grade of ✔ or + *does not guarantee* that the set is done correctly; it just means that the

set appears to be on the right track. I will always work through the correct solutions in class, so you will have a chance to evaluate how you did. In addition, we will often assign worksheets that you will complete during a class. These will be collected and graded in a similar fashion to the homework.

You are responsible for making sure that you understand the solutions—making mistakes, and learning from them, is much less expensive on the homework sets than on the exams!

Working collaboratively

I have no objection to your working on homework problems collaboratively; the set you turn in must, however, be your own. If you do work on homework solutions in a group, you must list your collaborators and describe their contributions. Please refer to the "Spartan Code of Honor Academic Pledge" recently adopted by the Associated Students of Michigan State University (ASMSU)[1].

Group computational project

In addition to learning about stars, this course has two other ancillary goals:

1. learning to solve complex problems numerically; and

2. learning to work collaboratively on larger projects.

Computation has become an indispensable component of modern science. While many sophisticated libraries of computational software, such as MatLab, are readily available, a scientist must understand *how* the algorithms work. Collaborative work is now the norm in many fields of science. A scientist must know how to work effectively as part of a team; indeed, this skill is essential for any technical career.

To develop your competence in these areas, you will work in teams of four to complete progressively more sophisticated computational projects over the semester. For each project, your team will submit your code (`Python`) and a brief report. You will be asked to review, using CATME, the performance of your team and teammates; these reviews will form part of your grade for each project.

We envision assigning three group projects during the semester. Projects are due at the end of the day on the dates indicated in the table.

[1] The text of the pledge is available on the login screen for D2L.

Project	Title	Due
1	Ordinary differential equations: Kepler's problem	4 Oct
2	The mass-radius relation for white dwarfs	15 Nov
3	The low-mass main sequence	6 Dec

These dates are subject to revision.

Assessments

Midterm There will be one midterm, tentatively scheduled for Thursday, 13 October. I'll confirm that date towards the end of September.

Final The final exam is scheduled for **Tuesday, 13 Dec, from 12:45–2:45** in 1420 BPS. The final will be cumulative, but weighted toward the latter half of the course.

Weights for the overall course grade

Homework	Project	In-Class	Midterm	Final
20%	20%	5%	20%	35%

Grading Standards

4.0 Mastery of subject, based on homework, exams, and in-class performance. Able to consistently apply concepts to solve problems. Ready for graduate-level coursework.

3.5 Demonstrates qualities described immediately above and below.

3.0 Generally understands concepts, but has some difficulties in applying them.

2.5 Demonstrates qualities described immediately above and below.

2.0 Incomplete or incorrect understanding of basic concepts.

Disability accommodations

Students who require disability accommodations should bring their VISA forms to Prof. Brown during the first week of classes. If you require accommodations but have not yet registered as a student with a disability, please register with the MSU Resource Center for Persons with Disabilities at https://www.rcpd.msu.edu/services/accommodations.

When there is a conflict

Disagreements and conflicts occur from time to time and are a fact of life; what is important is that they are swiftly and satisfactorily resolved. If you are unhappy about any aspect of the course, I propose that we follow a "24–48" rule: please bring your complaint to my attention promptly, within 24 hours of the issue arising; in turn, I shall evaluate your complaint and respond within 48 hours.

References—undergraduate-level stellar physics

Jeffrey O. Bennett, Megan O. Donahue, Nicholas Schneider, and Mark Voit. *The Cosmic Perspective*. Addison-Wesley, 7th edition, 2013.

Bradley W. Carroll and Dale A. Ostlie. *An Introduction to Modern Astrophysics*. Addison-Wesley, 2d edition, 2006.

Francis LeBlanc. *An Introduction to Stellar Astrophysics*. John Wiley & Sons, Ltd, West Sussex, UK, 2010.

A. C. Phillips. *The Physics of Stars*. John Wiley & Sons, Ltd, West Sussex, UK, 2d edition, 1999.

Dina Prialnik. *An Introduction to the Theory of Stellar Structure and Evolution*. Cambridge University Press, 2d edition, 2009.

References—graduate-level stellar physics

James Binney and Michael Merrifield. *Galactic Astronomy*. Princeton University Press, 1998.

Donald D. Clayton. *Principles of Stellar Evolution and Nucleosynthesis*. University of Chicago Press, 1983.

J. P. Cox. *Theory of Stellar Pulsation*. Princeton University Press, 1980.

Carl J. Hansen, Steven D. Kawaler, and Virginia Trimble. *Stellar Interiors*. Springer-Verlag, 2d edition, 2004.

R. Kippenhahn and A. Weigert. *Stellar Structure and Evolution*. Springer-Verlag, 1994.

D. Mihalas. *Stellar Atmospheres*. W. H. Freeman, 2d edition, 1978.

B. Paxton, P. Marchant, J. Schwab, E. B. Bauer, L. Bildsten, M. Cantiello, L. Dessart, R. Farmer, H. Hu, N. Langer, R. H. D. Townsend, D. M. Townsley, and F. X. Timmes. Modules for Experiments in Stellar Astrophysics (MESA): Binaries, Pulsations, and Explosions. *ApJS*, 220:15, September 2015. doi: 10.1088/0067-0049/220/1/15.

Bill Paxton, Lars Bildsten, Aaron Dotter, Falk Herwig, Pierre Lesaffre, and Frank Timmes. Modules for experiments in stellar astrophysics (MESA). *ApJS*, 192:3, January 2011.

Bill Paxton, Matteo Cantiello, Phil Arras, Lars Bildsten, Edward F. Brown, Aaron Dotter, Christopher Mankovich, M. H. Montgomery, Dennis Stello, F. X. Timmes, and Richard Townsend. Modules for experiments in stellar astrophysics (MESA): Planets, oscillations, rotation, and massive stars. *ApJS*, 208:4, 2013.

Stuart L. Shapiro and Saul A. Teukolsky. *Black Holes, White Dwarfs, and Neutron Stars*. Wiley, 1983.

Ya. B. Zel'dovich and I. D. Novikov. *Stars and Relativity*, volume 1 of *Relativistic Astrophysics*. University of Chicago Press, 1971.

References—coding (all free)

Software Carpentry. Lessons, 2014. URL http://software-carpentry.org/lessons.html.

Scott Chacon. *Pro Git*. Apress, 2009. URL http://git-scm.com/book.

Allen Downey. *Think Python*. Green Tea Press, 2013. URL http://www.greenteapress.com/thinkpython/thinkpython.html.

Bill Paxton. MESA: Modules for experiments in stellar astrophysics, 2014. URL http://mesa.sourceforge.net.

References—management & writing

Tom DeMarco. *The Deadline*. Dorset House, New York, 1997.

Steven Pinker. *The Sense of Style*. Viking Penguin, New York, 2014.

William Strunk, Jr. and E. B. White. *The Elements of Style*. Longman, 4th edition, 1999.

Edward R. Tufte. *The Visual Display of Quantitative Information*. Graphics Press, Chesire, CT, 2d edition, 2001.

Edward R. Tufte. *Beautiful Evidence*. Graphics Press, Chesire, CT, 2006.

G. Wilson, D. A. Aruliah, C. Titus Brown, N. P. Chue Hong, M. Davis, R. T. Guy, S. H. D. Haddock, K. Huff, I. M. Mitchell, M. Plumbley, B. Waugh, E. P. White, and P. Wilson. Best Practices for Scientific Computing. *ArXiv e-prints*, September 2012.

G. Wilson, J. Bryan, K. Cranston, J. Kitzes, L. Nederbragt, and T. K. Teal. Good Enough Practices in Scientific Computing. *ArXiv e-prints*, August 2016.