ASTR 367 – Astrophysics I – Fall 2021

Instructor: Dr. Maura McLaughlin

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Office hours: Please make an appointment at http://calendly.com/mamclaughlin.

Class times: M/W/F 0930-1020 in G04 White Hall

Aim: The goal of this course is to give you a good understanding of stellar properties, how stars generate energy, and how stars are born and die. We will become familiar with the properties (e.g. temperatures, ages, chemical compositions) of stars and the different states of matter that make up stars. We will understand hydrostatic equilibrium, nuclear fusion and energy transport. We will follow the lifecycles of different types of stars and understand the properties of the different end-points.

We will concentrate on understanding the physics of stars using simple calculations covering a very large range of physical principles. Many of our calculations will be order-of-magnitude and back-of-the-envelope. Secondary goals of the course are to understand what the current important problems in the field are, and to be able to interpret and communicate scientific results that are related to the topics we will cover.

While this course is designed to prepare students for careers as astrophysicists, the physics we will cover has a very broad range of applications, and the approach to problems should help in tackling difficult problems in many areas of physics.

Prerequisites: No astronomy knowledge is required. Introductory physics and calculus are mandatory. Modern physics is desirable but not required.

Text: The textbook for this course is *An Introduction to the Theory of Stellar Structure and Evolution* by Prialnik. Other textbooks that I will use are (on reserve at the library):

An Introduction to Modern Astrophysics by Carroll and Ostlie
Radiative Processes in Astrophysics by Rybicki and Lightman
Principles and Stellar Evolution and Nucleosynthesis by Clayton
Black Holes, White Dwarfs and Neutron Stars by Shapiro and Teukolsky
Introductory Astronomy and Astrophysics by Zeilik and Gregory

Homework and Exams: Homework will be assigned roughly weekly, to be due IN CLASS roughly one week later. I encourage you to talk with each other about the homework, but the actual solutions must be your own. Late homework will not be accepted, but I will drop your lowest one at the end of the semester. There will be two in-class exams and a final exam. The in-class exams will not be cumulative but the final one will be (though it will mostly cover the material in the last third of the course). These obviously must be done completely on your own! If you cannot make an exam, please let me know in advance so you can take a makeup exam in advance. If you miss the exam without letting me know in advance you will receive a zero grade.

Attendance: There is no specific attendance requirement for this course. However, since we will have lots of class discussions and since I will pull material from several different sources for the lectures, you will do much better in the course if you attend.

Grading: Your grade will be comprised of the following parts:

40% Homework
10% Class Participation
15% Exam 1
15% Exam 2
20% Exam 3

You will get at least the following letter grades for the following percentage grades in this course.

85-100% A
75-85% B
65-75% C
50-65% D
<50% F

Syllabus:

Aug. 18, 20: Introduction and Overview. The scale of the universe, astrophysical units, distances, measuring brightnesses and luminosities, colors, the HR diagram *(Ch. 1)*

Aug. 23: Assumptions. Physical assumptions about stars to make our lives easier! (*Ch. 1*)

Aug. 25, 28: Equations of Stellar Structure. Hydrostatic equilibrium, the virial theorem, ideal gas equation of state. (*Ch. 2*)

Aug. 30, Sept. 1: Basic properties of stars and dependencies. Characteristic timescales for evolution, mass-radius and mass-luminosity relations, minimum and maximum stellar masses. *(Ch. 2)*

Sept. 3, 10: Gas and radiation. Equations of state, sources of pressure in stars, radiative transfer. (*Ch. 2*)

Sept. 13, 15, 17: Nuclear Fusion. Processes for energy generation in stars. (*Ch. 3*)

Sept. 20: Catch-Up, Review, and Problem Solving

Sept. 22: In-class Exam

Sept. 24, 27, 29: Energy transport in stars. Radiation, convection, conduction. *(Ch.5, 6)*

Oct. 1, 4: Homology relations. Relationships between stellar properties. Schematic picture of stellar evolution. (*Ch. 7*)

Oct. 6, 8, 11: Stellar Evolution. Life on the main sequence, post-main sequence evolution *(Ch. 9)*

Oct. 13, 18, 20: Stellar modeling and projects.

Oct. 22: Review and problem solving

Oct. 25: In-class Exam

Oct. 27, Nov. 3: Star formation. Processes of formation (criteria, timescales, and properties) *(Ch. 12)*

Nov. 5, 8: Stellar Pulsations. Cepheids, non-radial pulsations, astroseismology *(Ch. 9)*

Nov. 8, 10: Stellar death. Supernovae and their manifestations *(Ch. 10)*

Nov. 12, 15 Compact Objects: Degeneracy pressure and white dwarfs *(Ch. 9)*

Nov. 17, 19: Compact Objects and Relativity Neutron stars and black holes *(Ch. 10)*

Nov. 29, Dec. 1: Binary star systems. Accretion, Roche lobes, CVs, novae *(Ch. 11)*

Dec. 3: The Sun. Sunspots, the solar cycle, solar evolution

Dec. 6, 8: Review and Problem Solving

Dec. 14: Final Exam (2 - 4 pm)

Social Justice Statement: The West Virginia University community is committed to creating and fostering a positive learning and working environment based on open communication, mutual respect, and inclusion.

If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with the Office of Accessibility Services(304-293-6700). For more information on West Virginia University's Diversity, Equity, and Inclusion initiatives, please see http://diversity.wvu.edu/.

I encourage any student who feels intimidated, out of place, or who could use any type of learning assistance, to come and talk to me. **Astrophysics is for everybody!**