Physics 354 — Astrophysics
Spring 09

Instructor: Jeff Wilkerson
Office: Valders 272G
Office Phone: 1226
e_mail: wilkerje@luther.edu

Office Hours:	Monday 2:30 – 3:30
	Tuesday 8:30 – 9:30
	Wednesday 1:30 – 2:30
	Thursday 11:30 – 12:30
	Friday 12:00 –1:30

Course Details:

Meets TTh, 12:45-2:15 in V176. Your course text is *An Introduction to Modern Astrophysics 2nd Edition,* Carroll and Ostlie. Your grade will be determined by the following weighting:

2 exams	**40%**
Homework	**15%**
6 Projects	**45%**

The exams will not be strictly cumulative but many topics, such as astronomical measures, will need to be used throughout the course. You will be responsible for most of the material from Part 1 of your text throughout the course. The exams are scheduled for the following dates:

Exam 1	Mar. 19
Exam 2	Final Time

"Homework" refers to problems you solve as you are accustomed to doing in your other physics classes. As usual, feel free to work on these in groups but the written work you turn in should be your own. There will be six to eight homework assignments during the course. Projects will be completed individually or in groups of two or three and will be observational projects using the rooftop observing equipment, observations you make using simple equipment or data downloaded from a database. There will be 6 of these.

The course can be roughly divided into five sections. We do not have time to cover the material thoroughly. The universe is a big place. Thus, we will select representative topics from different areas, using them as examples of how physical models can be developed for astronomical systems.

SECTION 1: BASIC OBSERVATIONS, SYSTEMS OF MEASURE AND OBSERVATIONAL TOOLS.

Here we will cover material from Sections 1.2 and 1.3, Chapter 3 and some ideas from Chapter 6. We will supplement this material fairly heavily. In particular we will add some ideas about the celestial sphere to the material from Chapter 1 and we will treat Chapter 6 very differently. Instead of spending so much time thinking telescope design we will be more interested in the function of CCD cameras and the processing of data from these cameras. These ideas will help you with your projects. We will spend about two weeks on this material.

Project 1: Measuring the Duration of the Sidereal Day

Project 2: Using Solar and Planetary Positions to Model the Solar System

SECTION 2: THE SOLAR SYSTEM

We will be interested primarily in orbits and celestial mechanics. As such this section of the course is primarily from Chapter 2 of your text. We will spend a very brief time on comparative planetology, looking at the similarities and differences in the physical properties of the planets. Here we will condense the biggest, broadest ideas of Chapters 20 through 23 into about a single day of class. We will spend about two weeks on this material.

Project 3: Orbit of the Moon

SECTION 3: THE NATURE OF STARS.

Here is the heart of the course. Many one-semester astrophysics courses are devoted entirely to this topic. In your text the material can be found in Chapters 8,7.12,and ***10****. Most textbooks devote something similar. The Bowers and Deeming book is devoted almost entirely to the nature of stars. We will compile the vast observational data pertaining to stellar systems and we will use that data and our knowledge of physical law to build models of stars. We spend the bulk of our time working in Chapter 10. A lifetime could be spent working with the material in this single chapter. There is hardly a better example of how simple differential equations can be used to build a beautiful model of a physical system of a star. We likely won't have time to do any of Chapter 14 but is a wonderful extension of Chapter 10 and you should look at it when you have the time and the inclination. Chapter 14 extends the mathematical models of Chapter 10 to a system that is out of hydrostatic equilibrium. See especially Section 14.3. Be prepared to weep at the beauty. We will spend about four weeks here, maybe five.*

Project 4: Building HR Diagrams

SECTION 4: LATE STAGES OF STELLAR EVOLUTION AND THE END STATES OF STARS.

Our focus here will be what happens when the fuel powering stellar luminosity runs short. Your textbook treats this material in : Chapters 13,15,16,17— especially ***15.3,15.4,15.6*** *and* ***16.3.*** *It is in this section that we will encounter the most physics that is new for many of you – general relativity and quantum statistics. Maybe we can do this in two weeks but we'll need to cut it pretty short. Once again this an field of study that could easily have a year-long course devoted to it and still not be close to exhausted.*

SECTION 5: GALAXIES AND COSMOLOGY.

We will study the structure and dynamics of our galaxy and look at how our galaxy compares to the many galaxies known. We will look at the evidence for dark matter and study Big Bang cosmology. This material is covered in Chapters 24, 27, and 29 of your textbook. Hopefully we have about three weeks to spend here.

Project 5: Using Star Clusters to Determine the Geometry of the Galaxy

Project 6: Mapping Dust in the Galaxy

Books of Interest

Textbook of Astronomy and Astrophysics with Elements of Cosmology by V.B. Bhatia. We have used this book as the course text in the past. It covers all the same topics as your text in a slimmer, more affordable volume but the coverage is not as detailed as we would like.

Introductory Astronomy and Astrophysics, Zeilik, Gregory and Smith. This book is often used for a course at this level. Hits all the topics. Not much depth and very light on calculation.

The Physical Universe, Shu. A good rule of thumb is that anything written by Frank Shu is worth reading. This text is comprehensive and enjoyable to read. It is somewhat more physics-oriented than other texts but the level of math is lower. It is worth reading just for the *philosophical comments* at the ends of chapters.

Discovering the Universe, Comins and Kaufmann. We use this as the text for Science 121. Little math and very little physics but a good introduction to astronomical concepts. It will be our primary resource for the introduction to the course.

Foundations of Astronomy, Seeds. Another introductory text. His treatment of Brahe, Kepler and Galileo is outstanding.

Astrophysical Concepts, Harwit. The level of this text is close to the level of the course text. Harwit presents little in the way of standard astronomy, opting instead to present the physics and math behind calculations involving astrophysical systems. This is a good book and contains a lot of information useful for solving tough problems but I find it difficult to just pick up and read.

Contemporary Astronomy, Pasachoff. This book utilizes little or no math and requires little knowledge of physics but for a pleasurable, easy to read tour of the universe, it can't be topped.

Radiative Processes in Astrophysics, Rybicki and Lightman. A standard graduate level text on emission, absorption and scattering of electromagnetic radiation.

The Physics of Astrophysics, Shu. A relatively new graduate level text. The first volume covers the same material as Rybicki and Lightman above. The second volume covers gas dynamics.

Astrophysics 1: *Stars*, Bowers and Deeming. A text on stellar structure and evolution that is at just about the right level of complexity.

High Energy Astrophysics, Longair. This book manages to be sophisticated in its approach without getting bogged down in calculation. The premise of the book is tracing the origin of cosmic rays but Longair does a fine job of covering detector techniques, radiative processes and the Milky Way. I can thoroughly enjoy sitting down reading straight through this book.

Black Holes, White Dwarfs and Neutron Stars, Shapiro and Teukolsky. The name pretty much says it all. It's just about the only real text on the subject of compact objects. It is getting pretty dated.

Galactic Astronomy, Mihalis and Binney. An outstanding tour of the Milky Way. This book is typically used as a graduate text but the level is easily within reach of upper level undergraduates. The chapters work well as stand alone units on various aspects of the Milky Way.

The Early Universe, Kolb and Turner. This is the best textbook that I've found dealing strictly with modern cosmology. It's at the graduate level and the field is changing rapidly enough that any book on this subject will become quickly dated but this text offers a solid introduction to cosmology.

Physical Cosmology, Peebles. Another graduate level cosmology text.

Burnham's Celestial Handbook, Burnham. This observer's guide is an absolute treasure for those wishing to hunt down deep sky objects with a small telescope. The book is rather old, so some of the material describing the physical nature of the objects is out of date but as a deep sky guide *Burnham's* is first rate.

Handbook of CCD Astronomy, Howell. This book introduces CCD cameras at a technical level. It is a good introduction to how they are used in astronomy.

The Handbook of Astronomical Image Processing, Berry and Burnell. This book comes with image processing software. It designed for backyard astronomers to use and is a great introduction to the processing of images in a practical way. It covers all the whys and hows of making pretty pictures as well as getting images ready use as sources of data.