Physics 456: Astrophysics
Spring 2016

Meeting: Trexler 272 — Time: MWF 8:30–9:30 AM
Instructor: Matthew C. Fleenor — Office: Trexler 266D
email: fleenor@roanoke.edu — Office Hours: W 1.15 – 4.00pm
R 1.00 – 2.30pm, or by appt.

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Required Readings: Astrophysics In a Nutshell, Dan Maoz; ISBN 0-495-01578-4
Heart of Darkness, Jeremiah Ostriker & Simon Mitton; ISBN 978-0-691-13430-7

Required Prerequisites: Physics 202

I. Components of Learning

There are several factors that make a course "good" (by good, I mean a healthy combination of the intellectual and the affective). Good courses are also clear about their essential components. Below is an attempt to be clear about how will I operate within PHYS 456, as well as my expectations of a student who is enrolled in PHYS 456.

Descriptions

Aspiration: Perhaps no other field demands such a comprehensive grasp of all realms of physical law than astrophysics. While an understanding of classical mechanics and electrodynamics are quite obvious, it is not commonly understood that most astrophysical phenomena also involve quantum, chemical, and statistical physics. It is somewhat daunting, but all the more invigorating, to think that these normal segregated branches of physics come together in the examination of the heavens. Furthermore, our capabilities to make order-of-magnitude estimates are taxed to the hilt when considering the field of astrophysics. Yet, these are the things of which physicists are made. I hope you are excited to have the opportunity to grow in these needed ways through the coursework this semester.

Expected Learning Objectives: Successful students will–

(1) describe the basic evolutionary process for main-sequence stars.

(2) calculate the masses and luminosities from general scaling relations for main-sequence evolution.

(3) synthesize basic quantum phenomena to explain stellar processes like energy generation, cooling, and late-evolution, pressure support.

(4) analyze observations of interacting binary systems to determine stellar masses and predict evolutionary patterns.

(5) connect individual steps in stellar formation into a continuous process of cloud collapse and restabilization.

(6) explain 3 physical observations that lead to a deduction of the structure of the Milky Way galaxy.

(7) describe the basic observations of galaxy clusters that lead to the current coherent astrophysical picture.

(8) analyze the current extragalactic distance ladder and provide an informed opinion about its uncertainties.

(9) explain the theoretical framework and observational confirmations for the standard big bang cosmology.

(10) list three open questions related to observational proofs of dark matter and dark energy.

Attendance: Although roll will not be taken, daily attendance is expected. Due to the mathematically rigorous nature of the course, you may not miss more than four classes without a legal excuse (court, hospital, police, etc.). Late arrivals greater than 10 minutes will constitute an official absence. The fifth absence for which there is no legal excuse will constitute your (forced) withdrawal from the course.

Office Hours: Please take advantage of the office hours prescribed above, or make an appointment with me. Drop-ins (aka. 'academic drive-bys') are at the total mercy of my daily schedule, for which I have the freedom to say, "I'm too busy."

Inquire (N@R): I use the N@R environment extensively to place notes, announcements, assignments, proofs, solutions, links, and other course documents. Please do NOT forget to check N@R before you come to class or if you have a question about previous assignments.

Academic Integrity: I want to foster a mutual respect for the classroom hours that we have together. In light of this, please remember to turn off cell phones, PDAs, etc. during the class and come prepared. Refer to the "Academic Integrity" page on the RC website–
http://roanoke.edu/A-Z Index/Registrar/Policies and Information/Academic Integrity.htm
Included here is an explanation of how violations of the College's academic integrity policy are handled.

Grades: Standard letter grades (A–F) are assigned according to the following scale for this course: "A"(91–100), "B+"(88–90), "B"(83–87), "B–"(80–82), "C+"(78–79), "C"(74–78), "C–"(70-73), "D"(60–69), "F"(< 60).

II. Modes of Learning

Rubric

Your grade is determined according to the following distribution:

Exams (2, take-home)	30%	Problem Sets	25%
Final (in-class)	15%	On-line Quiz	12%
In-class Quiz ("weekly")	13%	Participation	5%

Descriptions

Exams: Two exams are designed for completion over a weekend without hindrance of class periods. Because the exams are take-home, you are trusted NOT to use the following aids: other persons, internet, solution manuals for textbooks. Beyond that, I encourage you to use notes, books, etc. The final exam will be given in class and focus on newer material, but it will also incorporate some cumulative material. Make-up exams will only be allowed as a result of a discussion with me beforehand or a note related to the emergency (death, hospitalization, misdemeanor, etc.) signed by a governing official (medical doctor, parent, law enforcer, etc.).

Problem Sets: Un-/assigned problems (like those in the problem sets) are "when and where" you will learn the course material. For better and for worse, there is no way to learn

the depth of the material within the one-hour sessions that we will have together. Due to the nature of problem solving, I expect that you will work together toward a solution. However, I also expect that you will create an original solution to each assigned problem. Substitutions and simplifications should NOT be left to the "reader" (that's me) to figure out. If necessary, words and phrases need to be properly placed so that I can follow your train of thought. Problem sets are your final draft essays and/or compositions that display the fruit of your higher-level critical thinking skills, so you need to view them in that light. If you do not, I will return them to you for completion. NOTE: the submitted problems are ALMOST EQUAL in weight to the two exams.

In-class Quizzes: Weekly quizzes (FRIs) are completed individually in-class and graded. The quiz will consist of one partial problem from the problem set and/or class discussion, which contain the more important concepts and/or phenomena.

On-line Quizzes: Weekly quizzes (TUE and THU nights) are completed on-line and graded within the N@R environment. The quizzes will consist of a few multiple choice questions from the required reading. There will be page numbers announced and the quiz will be open-book.

Participation: There are lots of opportunities to participate within the course. Your attendance in class, your collaboration during group assignments, and your responsiveness during discussion are all forms of "participation". The completion of all on-line assignments, the watching of all audio-video lectures, and the submission of all problem sets, regardless of the grade, are also forms of participation. Please don't miss your chance to learn.

III. Daily Course Outline

In what follows, you will see the plan for working through the course. Each course meeting provides a section of the text, a conceptual topic, and a homework problem to reinforce the topic. Quizzes and Exams are also marked on the course outline, so please refer to it often. The bold-faced class periods require the watching of an audio-video lecture BEFORE class. The italics class periods denote a class discussion on the Heart of Darkness and an in-class quiz. If there are deviations from the following outline, I will certainly draw your attention to them.

456: Astrophysics Outline, SPR 2016

Week	Date	Chapter	Topic	Homework
	18-Jan	1. Introduction	**Units, Conversions, Dimensional Analysis**	1.1
1	20-Jan		1.1 Observational Techniques	Planck Exerc
	22-Jan	2. Stellar	2.1 Blackbody Radiation	
	25-Jan	Observations	**2.2 Measurement of Stellar Parameters**	2.3
2	27-Jan		2.3 Hertzsprung-Russell Diagram	
	29-Jan		*Heart of Darkness: Preface and Prologue*	
	1-Feb	3. Stellar	**3.1 Hydrostatic Equilibrium/ Virial Theorem**	
3	3-Feb	Physics	3.2-3 Mass Continuity & Radiative Transport	
	5-Feb		*Heart of Darkness: 1, Einstein's Toolkit*	
	8-Feb		**3.4-5 E Conservation & Stellar Structure**	
4	10-Feb		3.6-7 Equations of State & Opacity	
	12-Feb		*Heart of Darkness: 2, Realm of the Nebulae*	
	15-Feb		**3.8 Scaling Relations for MS Stars**	C. 1-3
5	17-Feb		3.9—3.12 Internal Stellar Processes	Take Home
	19-Feb	4. Stellar	*Heart of Darkness: 3, Let's Do Cosmology!*	Midterm Exam 1
	22-Feb	Evolution	4.1 Stellar Evolution	
6	24-Feb		**4.2 White Dwarfs**	
	26-Feb		4.3 Supernovae and Neutron Stars	
	29-Feb		**4.4 Pulsars & Supernova Remnants**	
7	2-Mar		4.5—4.6 Black Holes & Interacting Systems	
	4-Mar		*Heart of Darkness: 4, Discovering Big Bang*	
	7-Mar			
8	9-Mar	**No Classes – Spring Break**		
	11-Mar			
	14-Mar	5. Formation,	**5.1—5.2 Cloud Collapse, Formation, & HII**	
9	16-Mar	HII/Interstellar	5.3—5.4 ISM Components & Dynamics	
	18-Mar	Regions	*Heart of Darkness: 5, Origin of Structure*	
	21-Mar	6. Milky Way	**6.1—6.2 MWG Structure & Demographics**	C. 4 – 6
10	23-Mar	& Galaxies	6.3—6.4 AGN, Quasars, Groups, Clusters	Take Home
	25-Mar	**No Classes – Good Friday**		Midterm Exam 2
	28-Mar	7. Cosmology:	7.1-2 Olbers Paradox & Distance Scales	
11	30-Mar	Observations	**7.3-4 Hubble's Law & Age of the Universe**	
	1-Apr		*Heart of Darkness: 6, Dark Matter*	
	4-Apr	8. Big Bang	**8.1 Friedman-Robertson-Walker Metric**	
12	6-Apr	Cosmology	8.2 Friedman Equations	
	8-Apr		*Heart of Darkness: 7, Dark Energy*	
	11-Apr		**8.3—8.4 History & Future of the Universe**	
13	13-Apr		8.5 Dark Energy & the Accelerating Universe	
	15-Apr		*Heart of Darkness: 8, The Modern Paradigm*	
	18-Apr	9. Tests &	**9.1 Cosmological Redshift & Hubble's Law**	
14	20-Apr	Probes of BB	9.2 The Cosmic Microwave Background	
	22-Apr	Cosmology	9.3 Anisotropy of the CMB	
15	25-Apr		*Heart of Darkness: 9, The Frontier*	
	3-May	**In-class, Non-cumulative Final Exam 8.30 – 11.30**		