Physics 430: Astrophysics
Spring 2022

Meeting: Trexler 272 Time: MWF 1:10 – 2:10 PM Instructor: Matthew C. Fleenor
Office: Trexler 266D email: fleenor@roanoke.edu Office Hours: W 2.15 – 4.00pm
F 2.00 – 3.30pm, or by appt.
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Required Reading: *Astrophysics for Physicists*, A. R. Choudhuri; ISBN 978-0-521-81553-6
Required Prerequisites: Physics 203

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 430, as well as my expectations of a student who is enrolled in PHYS 430.

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: I will aspire to track daily attendance, and the following modes of learning also highlight a student's presence or absence: group work, discussion, and quizzes within the class hour. You are allowed a total of 3 absences (either un/excused) for which I do not require a note, but only an email ahead of time forewarning me of your absence (if possible). *At the fourth un/excused absence, I will request a meeting with you and send an email to you, your Advisor, and the Registrar alerting them of the situation.* After the fifth absence, you will be dropped (forcibly, with a "DF" or "DP," or willingly with a "W" before the ninth week) from the class. Besides the 'Participation' portion of the grade, one makes the best case for a "+" with a history of regular attendance and interest. Late arrivals greater than 10 minutes will constitute an official absence. The usual attendance policy above has been modified because we are in the season of a global pandemic (COVID). Please understand and abide by the following:

Face coverings/masks must be worn over the mouth and nose by all students and instructors in classrooms and hallways of academic buildings. By wearing face coverings, we protect our college community and its most vulnerable members. Students who come to class without a face mask that is being worn properly will be asked to leave and will be readmitted only after they are wearing one.

Also,

If you have a temperature of 100.4 or higher or other coronavirus symptoms, <u>don't come to class</u>. Call Health Services IMMEDIATELY. Do not come to class or go to any public area on campus. Do keep up with all readings, assignments, and deadlines. In order for your absence to be excused, you must give Health Services permission to notify me that you have consulted them about coronavirus symptoms. If Health Services informs you that you should isolate and not attend class for multiple days or weeks, inform me so that we can make a plan to keep you current in the course. All absences caused by consultation with Health Services about coronavirus symptoms or isolation ordered by Health Services will be excused.

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

Academic Integrity: I foster a mutual respect for the classroom hours that we have together. In light of this, please remember to silence cell phones, electronic devices, laptops, etc. during class and come prepared. Please ask if you want to use these devices for educational purposes in class. NOTE: As you might guess, academic courses conducted within the global pandemic have seen an increase in the numbers of AI charges. Traditionally, physicists (in particular) maintain a high-level of personal and community integrity. Part of your development as an aspiring physicist is personal integrity and responsibility.

Refer to the "Academic Integrity" page on the RC website–

https://www.roanoke.edu/inside/a-z_index/academic_integrity

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 NQR 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 any audio-video lectures, and the submission of all problem sets, regardless of the grade, are also forms of participation. Your TWO conversation reviews (or similar talks) are included here also. 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.

430: Astrophysics Outline, SPR 2022

Wk	Date	Chapter	Topic	HW	In-Class
1	17-Jan 19-Jan 21-Jan	1. Introduction	1.1-3,8 Units & Dimensional Analysis 1.4-7 Observational Techniques	Planck 1.1	1.2 1.3
2	24-Jan 26-Jan 28-Jan	2. Radiative Transfer	2.1-3 Radiative Transfer, Thermal Equilibrium 2.4,7 Radiative Transfer through Atmosphere 2.5-6 Radiative Energy Transport of Interior	2.1 2.3	2.4 2.6
3	31-Jan 2-Feb 4-Feb	3. Stellar Astrophysics I	3.1-2 Hydrostatic Equilibrium/ Virial Theorem 3.3-4 Mass Continuity & Radiative Transport 3.5-6 Observational Data on Stars		
4	7-Feb 9-Feb 11-Feb	4. Stellar Astrophysics II	4.1-3 Nuclear Reactions in Star 4.4-4.6 Stellar modeling & Binary systems 4.8-9 Stellar Rotation & Magnetic Fields		
5	14-Feb 16-Feb 18-Feb	5. End States of Stellar Collapse	5.1-5.3 Late Evolution Degeneracy Pressure 4.7, 5.4 Supernovae, Neutron Drip, Black Hole 5.5-6 Pulsars, X-ray Binaries, Grav Waves	Take Home MT Ex 1	
6	21-Feb 23-Feb 25-Feb	6. Milky Way & Interstellar Matter	6.1-3 MWG Structure & Dynamics 6.4-6 ISM Components & Dynamics 6.7-8 Magnetic Fields, Cosmic Rays, Thermal		
7	28-Feb 2-Mar 4-Mar	7. Elements of Stellar Dynamics	7.1-3 Virial Theorem & Relaxation 7.4-5 Boltzmann & Gravitational Equilibrium 7.6 Jean's Equation		

8	7-Mar 9-Mar 11-Mar	**No Classes – Spring Break**			
9	14-Mar 16-Mar 18-Mar				
10	21-Mar 23-Mar 25-Mar			Take Home MT Ex 2	
11	28-Mar 30-Mar 1-Apr				
12	4-Apr 6-Apr 8-Apr				
13	11-Apr 13-Apr 15-Apr	**Good Friday, No Classes**			
14	18-Apr 20-Apr 22-Apr				
15	25-Apr				
	30-Apr	**In-class, Non-cumulative Final Exam 8.30 – 11.30**			