Syllabus Astronomy 303: Black Holes

Spring 2023

Instructor: Dr. Mario Gliozzi

Contact Information:

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General Student Learning Outcomes:

Astronomy 303 is part of the Natural Science without Lab Core Program and fulfills the requirement for a 3 credit science course. According to the GMU catalogue the purpose of general education courses is: "to educate, liberate, and broaden the mind, and to instill a lifelong love of learning." Core natural science courses engage students in scientific exploration; foster their curiosity; enhance their enthusiasm for science; and enable them to apply scientific knowledge and reasoning to personal, professional and public decision-making.

At the end of the semester, students should be able to:

1. *Understand how scientific inquiry is based on investigation of evidence from the natural world, and that scientific knowledge evolves based on new evidence and differs from personal and cultural beliefs.*
2. *Recognize the scope and limits of science.*
3. *Recognize and articulate the relationship between the natural sciences and society and the application of science to societal challenges (e.g., health, conservation, sustainability, energy, natural disasters, etc.).*
4. *Evaluate scientific information (e.g., distinguish primary and secondary sources, assess credibility and validity of information).*

Course Objectives and Student Learning Outcomes:

Astronomy 303 is a course dedicated to the qualitative understanding of black hole systems. The course is designed to build the necessary background to appreciate the differences between Newton's theory of gravity and Einstein's theory of relativity that predicts the existence of black holes. The course will focus on the history of black holes, their first evidence in astrophysical systems, the observational properties of stellar-mass black holes, and the technology associated with observations in the different bands of the electromagnetic spectrum. The course will also cover the main characteristics of supermassive black holes in active galactic nuclei, the feedback between black holes and their host galaxy, as well as the detection of gravitational waves.

Course Structure and Philosophy:

The course is studio style using the "flipped" approach. ***Outside the class, students are expected to read the material, watch short videos, and complete a quiz with weekly deadlines***. During the class sessions each week, students will be involved in several activities such as lecture tutorials, mini-experiments, and hands-on activities, which will introduce and reinforce the most important concepts, and highlight common misconceptions.
Often students will ***work in small groups*** randomly assigned. Working with others can be an effective way to learn, and importantly most jobs require some level of collaborative work. An important goal is becoming a lifelong learner, able to think broadly and deeply, and to communicate effectively with others.
To succeed it is important to ***dedicate adequate time and effort outside the class*** to study the basic concepts, which are further mastered through class activities. The level of engagement and commitment required for this class is greater than for a standard lecture; as with all things worth doing, it will require effort, attendance, and commitment.

Text Book:

Our main reference textbook will be an open educational resource: OpenStax Astronomy (https://openstax.org/details/books/astronomy).
Additional resources will be provided through Blackboard.

Blackboard & Technology requirements:

You will need reliable computer access to participate in this course: the course's material is delivered through Blackboard. You must be able to both upload and download documents. You will need to ***check your emails (use the GMU account) often and Blackboard at least weekly.*** For issues with Blackboard contact courses@gmu.edu, and the ITU Support Center (703 993-8870) for general help with information about technology.

Work Ethic & Policies:

Active learning courses require more participation and input by students than do traditional large lecture format courses. Astronomy 303 involves both individual and collaborative work. You are expected to contribute actively to group activities and to respect and value opinions and work of other group members.
You will need to participate fully each week by:

1) coming prepared to class and completing the weekly homework quiz;
2) completing all class activities and submitting reports in class.

There are three mandatory tests: two midterms and one comprehensive final. All tests will be taken in the proctored COS Testing Center (TC) in the basement of Planetary Hall (room 2). As a class, you will have an assigned temporal window to go to the TC and complete each exam.

Students with disabilities:

Students with documented disabilities or special should contact the instructor during the first week of class. Students who suspect they have disabilities that need accommodation should contact the Office of Disability Services at George Mason as soon as possible in order to get proper documentation.

Student resources:

Academic advising center – 703-993-2470
Campus counseling center – 703-993-2380
Office of Disability Services – 703-993-2474
Writing center – 703-993-1200
Math tutoring center – 703-993-1460
Office of Diversity, Inclusion, and Multicultural Education
Religious Holiday Calendar

Honor Code:

George Mason's Honor code states that "Student members of the George Mason University pledge not to cheat, plagiarize, steal, or lie in matters related to academic work." If you have questions about the meaning of these terms, please ask. We expect you to hold to this standard by carefully citing sources used in your work and by doing your own work on tests and individual assignments.

In an environment where group work is highly valued it can be difficult to sort out which policies apply. At a minimum follow these guidelines:

- Work identified as individual should be strictly your own.
- Cheating on exams or presenting another's work as your own (plagiarism) will result in a zero grade for the assignment.
- Students are expected to actively collaborate on assignments identified as group, but it is important that only students who actively participate are given credit. The group is responsible for ensuring that all members take part and assume responsibility for group assignments.
- Material that is drawn from written or electronic sources must be appropriately cited. For on-line discussion it is usually enough to simply reference a text page or web site. In a more formal paper a bibliography and appropriate in-text citations are mandatory. If in doubt about how to do this contact an instructor.

Grading System:

Graded assignments include both at-home and in class activities. The grade is computed as follows: 1) *Homework quizzes (10%),* and *2) in class activities (50%).* Adding up these assignments yields 60% of your final grade. The remaining 40% is provided by three mandatory exams. During the semester, no more than 3 missed activities can be made up out of class. *Partial credit* can be earned for late work (not for the quizzes): *up to 80% within one week*, 0% after one week. Texting, use of computers unrelated to class activities will result in systematic point deduction.

Type of Assignment	**Percentage of grade**	**Method of calculating**

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Homework quizzes (home)	10%	***Due Saturday at 23:59 pm*** ***<u>No temporal extensions</u>.***
In-class activities	50%	***Submission in class.*** ***Full credit for honest participation and demonstrating comprehension***
Exams 1, 2, 3	40%	***In the COS Testing Center***

Grading-Percentage based on calculations in table above:

A+=97-100
A = 93-97
A- = 90-93
B+ = 87-90
B = 83-87
B- = 80-83
C+ = 77-80
C = 73-77
C- = 70-73
D = 60-70
F = 0-60

Homework Quiz

Each week you must complete one homework quiz, made of multiple choice, multiple-answer, and ranking questions, that cover the most important concepts for the week. Please, take this homework seriously, and take the quiz only after you have studied the material and (possibly) without external help. Some questions in the tests are similar to those in the homework quiz. To encourage you to study on weekly basis (which is necessary for keeping up with the class and for a deeper understanding of the subject), *<u>no temporal extensions are allowed for the quiz submission.</u>*

In class activities grading system

A variety of activities (which may comprise lecture tutorials, mini-experiments, crosswords, visualization activities, video and audio analysis, etc.) will be performed in class to help you master the most important concepts of the course.

Grading rubric for class activities:

Results	Presentation	Points
Correct	The reasoning is correct and explicitly explained	25-23
Mostly correct	The reasoning is mostly correct and explained	22-20
Significant errors	The reasoning is either not correct are or not shown	19-17
Mostly incorrect	There are substantial misconceptions	< 17

Exams

There are three mandatory tests: two midterms and one comprehensive final. If the grade of the final test is better than one of the midterm tests, the lowest midterm grade will be dropped and the grade of the final will be counted twice. Exams are to be done completely individually and I expect full adherence to the honor code with no collaboration, no outside notes, etc. Your responses should come exclusively from your well-prepared and thoughtful brain. The three mandatory exams will be taken in the testing center in the basement of Planetary Hall (http://ttc.gmu.edu).
You will have a specific temporal *window* for each exam and there will be no extensions.

Schedule (subject to change)

Week	Weekly Learning Goals	Learning Support Tasks	Assessments
Jan 23	*Get familiar with active learning and get to know your classmates. Distinguish science from pseudoscience. Clarify misconceptions on BHs.*	**Activities:** graph interpretation, basic of excel; understanding common misconceptions of science.	**Activity submission Homework Quiz**
Jan 30	*Explore basic physics concepts & misconceptions. Get a working knowledge of the conservation laws.*	**Activities:** basics of vectors; physics in a nutshell Part I.	**Activity submission Homework Quiz**
Feb 6	*Understand and apply the gravitational law, and Kepler's laws.*	**Activities:** physics Part II: gravitational law; Kepler's laws.	**Activity submission Homework Quiz**
Feb 13	*Explain and distinguish light-matter interactions. Discuss the information inferred from the radiation.*	**Activities:** basics of light properties, atomic structure; information from spectra.	**Activity submission Homework Quiz**
Feb 20	*Describe the properties of telescopes and compare ground-based and space observatories..*	**Activities:** telescopes at different wavelengths; experiment on angular resolution.	**Activity submission Homework Quiz**
Feb 24-25	**EXAM 1 (in the COS Testing Center) on Weeks 1, 2, 3, 4**		

Feb 27	*Describe and explain the star evolution from protostar to compact object through the H-R diagram.*	**Activities:** experiment on parallax; the H-R diagram.	**Activity submission Homework Quiz**
Mar 6	*Describe and compare the different fates of stars: WD, NS, and BHs.*	**Activities:** different types of pressure in stars and compact objects; detection of pulsars.	**Activity submission Homework Quiz**
Mar 20	*Explain the basic concepts of special and general relativity. Compare Newton's to Einstein's gravity.*	**Activities:** key ideas of relativity; comparison of Newton's and Einstein's gravity.	**Activity submission Homework Quiz**
Mar 27	*Discuss the discovery and the observational properties of stellar mass black holes.* *Get familiar with the technology in the different bands.*	**Activities:** types of binary systems, mass measurements; BH properties at different wavelengths.	**Activity submission Homework Quiz**
Mar 31-Apr 1	**EXAM 2 (in the COS Testing Center) on Weeks 5, 6, 7, 8**		
Apr 3	*Describe the structure of the Galaxy and its supermassive black hole. Explain how astronomers inferred the existence of dark matter*	**Activities:** Galaxy components; Sgr A*; dark matter discovery.	**Activity submission Homework Quiz**
Apr 10	*Describe the discovery of quasars and explain the AGN classification in the unification model.* *Compare and contrast stellar and supermassive BHs.*	**Activities:** Hubble's law at work; AGN unification model; comparison of stellar and supermassive BHs.	**Activity submission Homework Quiz**
Apr 17	*Discuss recent Black Hole results: gravitational waves and visualization of the event horizon. Describe the interactions BH-galaxy.*	**Activities:** Evaluate scientific information related to BH in the news and peer-reviewed articles.	**Activity submission Homework Quiz**
Apr 24	*Explain the basic concepts related to primordial black holes and black hole evaporation.*	**Activities:** Analogy of thermodynamics and BH properties; quantum mechanics and BHs.	**Activity submission Homework Quiz**
May 1	*BH recent discoveries in your words*	**Activities:** Presentation of recent discoveries on BHs.	
May 5-6	**EXAM 3 (in the Testing Center) final and comprehensive**		