Syllabus Astronomy 303

Instructor: Dr. Mario Gliozzi

Contact Information:

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Safe Return to Campus

All students taking courses with a face-to-face component are required to take Safe Return to Campus Training prior to visiting campus. Training is available in Blackboard (https://mymason.gmu.edu). Students are required to follow the university's public health and safety precautions and procedures outlined on the university Safe Return to Campus webpage (www2.gmu.edu/safe-return-plan). Similarly, all students in face to face and hybrid courses must also complete the Mason COVID Health Check daily, seven days a week. The COVID Health Check system uses a color code system and students will receive either a Green, Yellow, or Red email response. Only students who receive a "green" notification are permitted to attend courses with a face-to-face component. If you suspect that you are sick or have been directed to self-isolate, please quarantine or get testing. Faculty are allowed to ask you to show them that you have received a Green email and are thereby permitted to be in class.

Course Objectives and Student Learning Outcomes:

Astronomy 303 is a course dedicated to the qualitative understanding 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 first evidence of astrophysical black hole 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 (AGN) and the feedback between black holes and their host galaxy.

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

1. have a working knowledge of the laws of motion and of conservation of energy and momentum, as well as the universal law of gravitation.
2. Describe and discuss in a conceptual way the main ideas of space, time, and gravity presented by Einstein.
3. Discuss the main processes of interaction between radiation and matter, and explain the information that can be inferred from electromagnetic radiation.

4. Outline the main stages of star birth, evolution, and death, and explain the differences between the types of pressure at work in stars and compact objects.
5. Describe the first detection of black holes, and explain which black hole properties can be constrained from multi-wavelength observations.
6. Discuss the discovery of quasars, and explain the different types AGN in the framework of the unification model. Compare and contrast the characteristics of stellar and supermassive black hole systems.
7. Explain the connection between black holes and their environment: coevolution BH-galaxy, and feedback from jets and winds.
8. Evaluate scientific information related to black holes system, including the first visualization of the event horizon and 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 do an homework 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 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%)*, *2) in class activities (50%)*, which include active participation and activities that are submitted in class. Adding up these two parts 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. There will be a 20% deduction for late arrivals within 15 minutes, 40% deduction within 30 minutes; beyond 30 minutes you will be marked absent.

Type of Assignment	**Percentage of grade**	**Method of calculating**
Homework quizzes (home)	10%	***Due each Saturday at 11:59 pm No temporal extensions.***
In-class activities + active participation	50%	***Full credit for honest participation and demonstrating comprehension Points are deducted for lack of participation, texting, being late.***
Exams 1, 2, 3	40%	***The first two exams are scheduled in the COS Testing Center***

Grading-Percentage based on calculations in table above:

A = 93-100
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), *no temporal extensions are allowed for the quiz submission.*

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 25	*Get familiar with active learning and get to know your classmates. Introduction to Black Holes.*	**Activities:** graph interpretation, basics of excel; understanding common misconception in science.	**Activity submission Homework Quiz**
Feb 1	*Explore basic physics concepts. Get a working knowledge of the conservation laws.*	**Activities:** basics on vectors; physics in a nutshell	**Activity submission Homework Quiz**
Feb 8	*Understand and apply the gravitational law, and Kepler's laws.*	**Activities:** gravitational law; Kepler's law through simulations.	**Activity submission Homework Quiz**
Feb 15	*Explain and distinguish light-matter interactions. Discuss the information inferred from the radiation.*	**Activities:** basics of light properties; information from spectra; atomic structure.	**Activity submission Homework Quiz**
Feb 22	*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 25,27	**EXAM 1 (in the COS Testing Center) on Weeks 1, 2, 3, 4**		
Mar 1	*Describe and explain the star evolution from protostar to compact object.*	**Activities:** experiment on parallax; H-R diagram.	**Activity submission Homework Quiz**
Mar 8	*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 15	*Explain the basic concepts of special and general relativity. Compare Newton's to Einstein's gravity.*	**Activities:** key ideas of relativity; comparison Newton's and Einstein gravity.	**Activity submission Homework Quiz**
Mar 21	*Discuss the discovery and the observational properties of stellar mass black holes. Get familiar with the technology in the different bands.*	**Activities:** binary systems comparison and mass measurement; BH properties at different wavelengths.	**Activity submission Homework Quiz**
Mar 25, 27	**EXAM 2 (in the COS Testing Center) on Weeks 5, 6, 7, 8**		
Mar 28	*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 5	*Describe the discovery of quasars and explain the AGN classification in the unification model. Compare & contrast stellar and supermassive BHs.*	**Activities:** Hubble's law at work; AGN unification model; comparison stellar and supermassive BHs.	**Activity submission Homework Quiz**
Apr 12	*Discuss recent Black Hole results: gravitational waves and visualization of the event horizon. Describe the interactions BH-galaxy: coevolution, impact of jets on large scale.*	**Activities:** evaluate scientific information related to BH in the news and peer-reviewed articles.	**Activity submission Homework Quiz**
Apr 19	*Explain the basic concepts related to primordial black holes and black hole evaporation.*	**Activities:** comparison thermodynamics and BH properties; quantum mechanics and BHs.	**Activity submission Homework Quiz**
Apr 26	**EXAM 3 (in class) final and comprehensive**		