Course Change Request

New Course Proposal

Date Submitted: 11/22/19 4:59 pm

Viewing: ASTR 303 : Black Holes

Last edit: 11/22/19 4:59 pm

Changes proposed by: prubin

Are you completing this form on someone else's behalf?

No

In Workflow

1. **PHYS UG Committee**
2. **PHYS Chair**
3. **SC Curriculum Committee**
4. SC Associate Dean
5. Assoc Provost-Undergraduate
6. Registrar-Courses
7. Banner

Approval Path

1. 04/25/20 7:50 pm Philip Rubin (prubin): Approved for PHYS UG Committee
2. 04/25/20 7:54 pm Paul So (paso): Approved for PHYS Chair

Effective Term: Fall 2020

Subject Code: ASTR - Astronomy

Course Number: 303

Bundled Courses:

Is this course replacing another course? No

Equivalent Courses:

Catalog Title: Black Holes

Banner Title: Black Holes

Will section titles vary by semester? No

Credits: 3

Schedule Type: Lecture

Hours of Lecture or Seminar per week: 3

Repeatable: May be only taken once for credit, limited to 3 attempts (N3)

Max Allowable Credits: 9

Default Grade Mode: Undergraduate Regular

Recommended Prerequisite(s):

Recommended Corequisite(s):

Required Prerequisite(s) / Corequisite(s) (Updates only):

Registrar's Office Use Only - Required Prerequisite(s)/Corequisite(s):

And/Or	(	Course/Test Code	Min Grade/Score	Academic Level	)	Concurrency?

Registration Restrictions (Updates only):

Registrar's Office Use Only - Registration Restrictions:

Field(s) of Study:

Class(es):

Level(s):

Degree(s):

School(s):

Catalog Description:

Introduction to black hole systems. Topics include qualitative understanding of gravity in Newton's and Einstein's perspectives, stellar evolution and compact objects, characteristics of stellar and supermassive black holes, observational evidence of black holes from electromagnetic radiation and gravitational waves.

Justification:

There is a great deal of general interest in the topic of black holes, and much expertise on the topic in the Department of Physics & Astronomy. It seems natural to offer a course on a topic in which interest and expertise coincide.

Does this course cover material which crosses into another department? No

Learning Outcomes:

Attach Syllabus

Astro303SyllabusFall2020_C.pdf

Additional Attachments

Staffing:

Gliozzi, Satyapal, Plavchan, Weingartner, Becker

Relationship to Existing Programs:

When approved, this course will be among the options for the revised astronomy minor, and just the second without requisites for those who aren't physics majors.

Relationship to Existing Courses:

The course stands alone, but could complement some of the 100-level introductory physics courses.

Additional Comments:

Reviewer Comments

Key: 16641

Syllabus Astronomy 303: Black Holes

Fall 2020

Instructor: Dr. Mario Gliozzi

Contact Information:

Office: 201C Planetary Hall
Tel: 703-993-4479
Email: mgliozzi@gmu.edu
Office hours in person: Monday 10:00 am - 12:00 pm. Additional office hours can be scheduled by appointment.

General Student Learning Outcomes:

Astronomy 303 is part of the core natural science 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 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. *Students will participate in mini-*

experiments, testing various hypotheses with systematic measurements, understanding the nature of scientific inquiry, as described in SLO1.

2. Describe and discuss in a conceptual way the main ideas of space, time, and gravity presented by Einstein. *Students will make a direct comparison between the theory gravity developed by Newton and the new interpretation proposed by Einstein, understanding how scientific knowledge evolves over time (SLO1) and its limits (SLO2).*
3. Discuss the main processes of interaction between radiation and matter, and explain the information that can be inferred from electromagnetic radiation. *Students will get familiar with current technologies utilized in astronomy, which have direct application in other fields (e.g., medical) and play an important role in our society in agreement with SLO3.*
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. *Students will compare sources of energies and efficiencies at work in astronomical objects with those familiar on Earth processes (SLO3).*
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. *Students will assess the credibility of scientific information from various sources, ranging from peer review articles to daily news (SLO4).*

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 homework 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 (5%)*, 2) *Active participation* (5%), *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. 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)	5%	***Due each Tuesday at 3:00 pm*** ***No temporal extensions.***
Active Participation	5%	***Points are deducted for lack of participation, texting, being late.***
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 = 93-100	C+ = 77-80
A- = 90-93	C = 73-77
B+ = 87-90	C- = 70-73
B = 83-87	D = 60-70
B- = 80-83	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.*

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. At the end of the class period, you will submit the daily assignment, which will be generally graded according to the 3-2-1-0 High Performance System:

- Score 2: Your work meets my expectations, is essentially correct and free of most major errors. No substantial feedback is necessary, but feel free to ask if you want any explanation.
- Score 1: Your work is missing some important components or has some important errors that need to be resolved before you can progress. Please meet me or an LA as soon as possible.
- Score 0: Your work was not submitted according to the directions or no meaningful attempt is evident in your work. Please meet with me or an LA as soon as possible.
- Score 3: Your work is exemplary and goes far beyond my expectations for this particular assignment. This score is rarely assigned and you should be very proud of your efforts.
- Important Note: Strive to earn a "2" on every assignment. A consistent "2" will earn an A for this portion of the grade.

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
Aug 31	*Get familiar with active learning and get to know your classmates.* *Introduction to Black Holes.*	**Discussion:** personal introductions **Activity:** discussion in pairs, clarifying misconceptions.	**Activity submission** **Homework Quiz**
Sept 7	*Explore basic physics concepts & misconceptions.* *Get a working knowledge of the conservation laws*	**Activity #1:** Concepts & misconceptions **Activity:** Mini-experiments	**Activity submission** **Homework Quiz**
Sept 14	*Understand and apply the laws of motion, the gravitational law, and Kepler's laws.*	**Activity + lecture tutorial**	**Activity submission** **Homework Quiz**
Sept 21	*Explain and distinguish light-matter interactions.* *Discuss the information inferred from the radiation.*	**Activity + lecture tutorial**	**Activity submission** **Homework Quiz**
Sept 28-29	**EXAM 1 (in the COS Testing Center) on Weeks 1, 2, 3, 4**		
Sept 28	*Describe and explain the star evolution from protostar to compact object.*	**Activity + lecture tutorial**	**Activity submission** **Homework Quiz**
Oct 5	*Explain the basic concepts of special and general relativity. Compare Newton's to Einstein's gravity.*	**Activity**	**Activity submission** **Homework Quiz**
Oct 12	*Discuss the discovery and the observational properties of stellar mass black holes.* *Get familiar with the technology in the different bands.*	**Activity + lecture tutorial**	**Activity submission** **Homework Quiz**
Oct 19	*Describe the discovery of quasars and explain the AGN classification in the unification model.* *Compare & contrast stellar and supermassive BHs.*	**Activity**	**Activity submission** **Homework Quiz**

Oct 26-27	**EXAM 2 (in the COS Testing Center) on Weeks 5, 6, 7, 8**		
Oct 26	*Describe the structure of the Galaxy and its supermassive black hole. Explain how astronomers inferred the existence of dark matter*	**Activity + lecture tutorial**	**Activity submission Homework Quiz**
Nov 2	*Discuss the interactions BH-galaxy: coevolution, impact of jets on large scale.*	**Activity**	**Activity submission Homework Quiz**
Nov 9	*Discuss recent Black Hole results: gravitational waves and visualization of the event horizon.*	**Activity**	**Activity submission Homework Quiz**
Nov 16	*Explain the basic concepts related to primordial black holes and black hole evaporation.*	**Activity**	**Activity submission Homework Quiz**
Nov 23-24	**EXAM 3 (in the Testing Center) final and comprehensive**		