ASTRO 130

Black Holes in the Universe

Sample Syllabus

Description

The semester is divided into roughly 4-week periods for each of the three major units:

Unit 1: Spacetime, Special and General Relativity – Newton's and Einstein's Theories of Gravity, Definition of Black Holes, Absoluteness of the Speed of Light, Time Dilation, Length Contraction, Mass Increase, the Twin Paradox, Equivalence Principle, Gravitational Time Dilation, Effects of Gravity on Light, Evidence of Relativity

Unit 2: Types of Black Holes and their Characteristics – How do Black Holes form, Binary Stars and Accretion Disks, Supermassive Black Holes in Centers of Galaxies, How to Detect a Black Hole, Active Galactic Nuclei, Jets

Unit 3: Evaporation of Black Holes, Wormholes and Time Travel – Gravitational Waves, Kerr Black Holes, Hawking Radiation, What's inside a black hole, Black holes that formed in the early universe, Wormholes and time travel.

You can work through the online material at a pace that suits you best, but be aware that at the end of each 5-week period, there will be an exam covering that unit's material (3 exams + the final exam). Exams are in multiple choice format. The final exam will be cumulative.

Objectives

This course is intended to introduce students to the predicted properties of black holes and the astronomical evidence for their existence. Along the way we will study modern ideas about the nature of space, time, and gravity. After taking this course, students should be able to:

- Describe the key ideas of special and general relativity and the evidence for each

- Understand the difference between Newton’s and Einstein's theories of gravity
- Explain what is a black hole, how one forms, and what happens near it and to objects falling into a black hole
- Describe the difference between stellar mass and supermassive black holes, and how to detect each type
- Explain what is an Active Galactic Nuclei and describe why black holes have jets
- Describe how black holes can loose energy through Hawking radiation and possibility of wormholes

We will spend the first few weeks discussing Einstein's ideas about space, time, and gravity since these ideas are absolutely critical for a proper understanding of black holes. Do not worry if black holes do not make an immediate appearance in the first couple weeks; they will be coming and will certainly be the main focus of the course.

Requirements

Please note that Astro 1 is a prerequisite for this class, and you will be expected to perform very simple mathematical calculations. Examples will be given in the course notes. Examples of the mathematical concepts we will use in this class are:

- Scientific notation
- Multiplying and dividing powers of 10
- Converting between different metric units
- Rearranging and solving simple equations, taking a quantity to a power

Grading

- Midterm Exams: 40%
- Final exam: 25%
- Homework: 25%
- Class participation: 10%

Exams

There will be 3 scheduled exams plus a cumulative final exam. Dates for the exams are:

- Exam 1: February 9-12
- Exam 2: March 23 - 26
- Exam 3: April 20 - 23

No make up exams are given except for serious medical emergencies or legitimate unavoidable conflicts related to university business (these must be documented).

Exams are closed book and closed notes; you are not allowed to use any webpages, notes, electronic devices, other people, or any other outside resources to assist you on the exam. You can have a pen/pencil and scratch paper to help work out some questions.

Final Exam: The final exam is cumulative,covering material across the entire semester. There are no make-ups for the final exam.

Homework

We will have homework assignments during the course. These will be announced one week before the due date.

I encourage you to start the work on the problem set by yourself as soon as it is assigned. Homework counts for 25% of your final grade! This means that you should take it seriously. Do not wait until the end of the time period to complete the homework. The homework assignments will take you several hours, so if you leave them to the last minute, you'll be in trouble—and it will be too late for you to ask for help. No extensions or make-ups will be given.

You are encouraged to discuss the homework problems on Piazza.

Participation

You will be graded on the basis of completion of a unit. You must complete the material for the relevant Unit before the exam period begins. You can do this at your own pace and convenience, however do be sure to allow enough time. It is probably best to do a bit each week, as opposed to leaving everything for the last day before the test period. In total, we expect about the same amount of your time to be required as in a traditional lecture class.

During the semester you must participate in a discussion on Piazza at least once. You can either post a question, or comment on a posted question. Only astronomy related questions count. You will not receive credit for questions related to the logistics of the class.

Grading

- > 93% = A
- 90 - 92.99% = A-
- 87 - 89.99% = B+
- 83 - 86.99% = B
- 80 - 82.99% = B-
- 75 - 79.99% = C+
- 65 - 74.99% = C
- 0 - 64.99% = D
- < 50 = F

Grades are not rounded in any way, and the scale is designed to give the highest grades possible at the end of the semester to everyone. There is no extra credit in this class.

Academic Integrity

Academic integrity is the pursuit of scholarly activity in an open, honest and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle. Consistent with this expectation, the University's Code of Conduct states that all students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts.

Academic integrity includes a commitment by all members of the University community not to engage in or tolerate acts of falsification, misrepresentation or deception. Such acts of dishonesty violate the fundamental ethical principles of the University community and compromise the worth of work completed by others.

Accommodating Disabilities

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. The Student Disability Resources (SDR) website provides contact information for every Penn State campus . For further information, please visit Student Disability Resources website.

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: See documentation guidelines . If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

Counseling and Psychological Services

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

- Counseling and Psychological Services at University Park (CAPS): 814-863-0395
- Counseling and Psychological Services at Commonwealth Campuses
- Penn State Crisis Line (Available 24 hrs, 7 days a week): 877-229-6400
- Crisis Text Line (Available 24 hrs, 7 days a week): Text LIONS to 741741

Educational Equity / Report Bias

Penn State takes great pride to foster a diverse and inclusive environment for students, faculty, and staff. Acts of intolerance, discrimination, or harassment due to age, ancestry, color, disability, gender, gender identity, national origin, race, religious belief, sexual orientation, or veteran status are not tolerated and can be reported through Educational Equity via the Report Bias website.