

Physics 569
Introduction to General Relativity
Spring 2022

Lectures: 9:30 AM - 10:45 PM TuThu in PAS 404

Instructor: Prof. Vasileios (Vasilis) Paschalidis

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Prof. Paschalidis' Office hours: TBD

Textbook: Carroll, *Spacetime and Geometry: An Introduction to General Relativity*

Further reading: Robert Wald, *General Relativity* (for mathematical rigor)
Misner, Thorne Wheeler, *Gravitation* (for an extended reference)

Course description: This is a graduate-level introduction to general relativity and will take place in person. We will cover most of the first five chapters of Carroll's "Spacetime and Geometry: An Introduction to General Relativity", and conclude with a brief survey of more advanced topics (chapters 6-8). The goal is for you to gain competency with the theory and learn about its physical predictions. The core topics are special relativity (Ch. 1), curved spacetime (Ch. 2-3), Einstein's equation (Ch. 4), and the Schwarzschild metric (stars, black holes, experimental tests) (Ch. 5). Survey topics may include general black holes, gravitational waves and cosmology.

Prerequisites: Multivariate differential and integral calculus are important for the class. The more physics and math you have mastered, the smoother and more beneficial the course is going to be for you. We will be introducing the formal mathematical machinery necessary for the course.

Course format: This is a traditional lecture course, except that I will sometimes ask you to do short calculations in class. There will be no need to take notes. The book is very good, and I will follow it very closely. The ideal way to learn is to read relevant sections from the book before class. At the end of each lecture I will be assigning reading for the following lecture.

Topics to be covered: Special relativity, manifolds, tensor calculus, curvature, gravity as curved spacetime, the Schwarzschild solution, general black holes, gravitational waves, cosmology.

Assignments and exam: There will be homework (approximately 1 problem set every week) and a take-home final exam. The **homework will be due on Thursdays at the end of class. You may upload a pdf scan of your homework on D2L if you desire.** You are encouraged to work together, especially in figuring out how to approach the problems and even solve them collaboratively. Collaborative effort will not be encouraged for the final exam. You are expected to work on your own for the final.

Course Objectives and Expected Learning Outcomes: At the end of this course, students will be able to:

- Exhibit command of tensor calculus.
- Have a foundational understanding of introductory general relativity to allow them to pursue research in the field.
- Understand the basic experiments that established the theory.
- Have a working knowledge of black holes and their properties.
- Exhibit working knowledge of the application of general relativity to cosmology.

Grading: Your course grade will be based on homeworks (60%), and a take-home final (40%).

Incomplete/Withdrawal: Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at <http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete> and <http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively.

Attendance: Class attendance is optional. General relativity is a topic that defies day-to-day intuition, so you will benefit from coming to class in order to ask questions about parts of the material you do not understand. By not coming to class you will miss out on any help other students will benefit from. In addition, your instructors are not required to explain to you what you missed by not coming to class. You are responsible for knowing everything that goes on in class, including announcements, course materials, handouts, what has been assigned as homework, as well as any hints, help, due dates, extensions, etc. Especially due dates could be changed, if the majority of the class has found a problem set particularly challenging.

If you have a legitimate reason for not attending on a given day, please let us know in advance. We may be able to give you the appropriate class notes. If you have cleared your absence with us in advance, make sure that you contact us promptly upon return to find out what you may have missed.

All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion.

Course Website: In this class we will make use of D2L. It is your responsibility to check D2L regularly for course announcements/updates and assignments.

Classroom Behavior Policy: To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

Some learning styles are best served by using personal electronics, such as laptops and iPads. These devices can be used ONLY for note taking. NO cellphones in class. Cellphones must be kept in a bag or pocket and on silent.

Threatening Behavior Policy: The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

Code of Academic Integrity: Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: <http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

UA Nondiscrimination and Anti-harassment Policy: The University is committed to creating and maintaining an environment free of discrimination; see <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>.

Accessibility and Accommodations: At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, <https://drc.arizona.edu/>) to establish reasonable accommodations.

Subject to Change Notice: Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.

Graduate Student Resources: The University of Arizona's Basic Needs Resources page is <http://basicneeds.arizona.edu/index.html>