

PHYS 430: General Relativity & Gravitation

Section 50513 – Spring 2024

Preliminary Syllabus

Instructor:	Prof. Kris Pardo	Class Location:	KAP 150
Email:	kmpardo@usc.edu	Class Day/Time:	W/F 10:00–11:50am
Office Location:	ACB 528	Textbook:	<i>A First Course in General Relativity</i>
Office Hours:	Thursdays 1-2pm		Bernard Schutz 3rd Edition

COURSE OVERVIEW & GENERAL INFORMATION

Welcome to PHYS 430: General Relativity & Gravitation! In this course, we will dive deep into Einstein's theory of general relativity. We will cover how to describe spacetime in mathematical terms, how spacetime bends according to the matter and energy it contains, and how that curvature tells matter how to move. We will address the implications of Einstein's theory – from black holes to gravitational waves to our expanding universe.

This course is designed specifically for upper-level physics majors who have not yet taken a course in general relativity. There are a number of mathematics and physics prerequisites. The course requires a solid background in vector calculus and linear algebra. However, the main mathematics of general relativity, differential geometry, will be taught as needed in this course. In addition, the course will assume a good background in classical mechanics, and electricity and magnetism. We will review special relativity at the beginning of the course, but the emphasis will be on general relativity. This material is not easy, but I hope that the class will be rewarding.

TEXTBOOK & LECTURE NOTES

The assigned textbook for this course is *A First Course in General Relativity* by Bernard Schutz. This book is an excellent introduction to the subject and has recently been updated to include all the latest details on gravitational wave astronomy. I will follow the book closely, and many of your homework and quiz problems will be inspired by the book (as well as the other books listed below).

I will also provide lecture notes, uploaded to Blackboard after each class. These will include some material not in Schutz.

Beyond the main textbook, the following supplemental textbooks may prove useful to you:

- *Gravity: An Introduction to Einstein's General Relativity*, by James Hartle. This textbook is very commonly used for courses like these, and features excellent physics-based discussions of the material. Ultimately, I chose Schutz because it got to the tensor notation more quickly!
- *Spacetime and Geometry*, by Sean Carroll. This is a graduate-level text that is very well written, and should still be accessible to undergraduates.
- *Gravitation*, by Misner, Thorne, and Wheeler. This is the classic resource for GR. It is very hard to read, but it probably has the answer to every question you ever have about GR.
- *Einstein Gravity in a Nutshell*, by Zee. Zee is known for his humor and nice explanations. This is a hefty, graduate-level book, but it could provide alternate explanations that you might find useful.

COURSE TOPICS

The plan is to cover the following chapters out of Schutz. We may skip some subsections, and we may not get to all of these chapters. The plan is to roughly go in order, but we may skip around a bit depending on how the class goes.

1. Special relativity
2. Vector analysis in special relativity
3. Tensor analysis in special relativity
5. Preface to curvature
6. Curved manifolds
8. The Einstein field equations
9. Fundamentals of gravitational radiation
11. Schwarzschild geometry and black holes
12. Gravitational wave astronomy
13. Cosmology

GRADING & EVALUATION

You will be able to access all your grades via [Blackboard](#). Your grade will be determined according to the following key:

- Class participation & quizzes – 20%
- Homework – 20%
- Midterm – 20%
- Final project/exam – 40%

Class participation & Quizzes

We will have daily in-class quizzes. These are meant to help you practice doing calculations in GR, and are not meant to be onerous (they should take less than 5 minutes per day). You will get 1 point for simply signing your name to the page and attempting the problem. You will get another point if you solve the problem correctly. If you score 80% overall, you will receive 100% in the class participation portion of your grade. Going higher than this number will give you extra credit.

If you have an excused absence that is approved ahead of time, then you can complete an alternate (more difficult) assignment to make up the points.

Homeworks

Homework will be assigned regularly, roughly once per week. The due dates will be determined as we progress in the course. Your solutions must be typed or hand-written. You will upload a scan/picture or pdf of your solutions to Blackboard. It is your responsibility to ensure that your solutions are legible.

The problems will come mostly from the textbook and other textbooks listed above. They will have a range of difficulties. I encourage you to attempt every problem! I also strongly encourage you to work together with your classmates on these problems. However, **you must submit your own work**.

Exams & Final project

There will be one midterm and one final exam. These may be take-home or in-person (TBD!). If they are in-person, the midterm will take place during our normally scheduled class on **March 7th**, and **the**

final exam is on Monday, May 6th, 8-10am. The midterm will cover the course material covered in the first half of the semester, and the final exam will cover the whole course.

In addition, you will have the option of submitting a final project in lieu of half of the final exam grade. Everyone must still take the final, but you can lessen the impact of the grade by submitting a final project as well. We will discuss this further as we get closer to the end of the semester.

FEEDBACK

Feedback regarding all aspects of this course is very much appreciated and welcome at any time. Please get in touch with me via email, after lectures, or during office hours. You can also anonymously submit feedback via this google form (link TBA once the semester starts!).

IMPORTANT DATES

- January 10 – Spring Semester classes begin
- January 26 – Last day to drop class without a mark of “W”, and last day to change enrolment option
- **March 7 – Midterm Exam**
- March 10 - March 17 – Spring Break
- March 29 – Last day to drop class with mark of “W”
- April 26 – Last day of classes
- **May 6, 8:00–10:00am – Final Exam**

ACADEMIC INTEGRITY

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask me if you are unsure about what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution. In this class, you are expected to submit work that demonstrates your individual mastery of the course concepts. Unless specifically designated as a 'group project', all assignments are expected to be completed individually.

DISABILITY ACCOMODATIONS

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

STUDENT SUPPORT SYSTEMS

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services

(though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-5086 or (213) 821-8298
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382) (HSC)
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 orotfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.