**UNIVERSITY OF MISSISSIPPI**
Department of Physics and Astronomy
GR II (Phys. 750) — Prof. Leo C. Stein — Spring 2020

**GR II Syllabus**

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| Class schedule: | TR 0800–0915, Lewis Hall room 109 |
| Office hours: | TBD, Lewis Hall room 205 |
| Course website: | https://duetosymmetry.com/teaching |
| Professor: | Leo C. Stein (you can call me "Leo" or "Dr. Stein") |
| Email: | ⟨lcstein@olemiss.edu⟩ |
| Office: | 205 Lewis Hall |
| Phone: | +1 (662) 915-1941 (x1941 on campus) |

## Texts

Just as there is no single best text on GR, there is no best text for a second course on GR. There are topics scattered throughout many textbooks that I'd like to cover.

- *Gravitation*, MTW
- *General relativity*, Wald
- *A Relativist's Toolkit*, Poisson
- *Gravity*, Poisson and Will (especially for post-Newtonian theory)
- *Numerical Relativity*, Baumgarte and Shapiro
- *Advanced General Relativity*, Stewart
- *Spinors and space-time*, Penrose and Rindler

You should also be comfortable with differential geometry textbooks. Here are a few well-known texts:

- *Differential Geometry*, Spivak
- *Introduction to Smooth Manifolds*, John M. Lee

Finally, GR is currently an active area of research, so there's a lot of stuff out in the journal literature that hasn't yet made it into a textbook.

## Course goals and learning outcome

Key concepts (time permitting): • Review of classical diff. geom. • maps, pullbacks, pushforwards, the "differential" • bundles • metrics, conformal transformations • connections • Lie groups, Killing vectors/tensors • submanifolds, congruences, integrability • 3+1, ADM, (Lagrangian and) Hamiltonian formulations • null surfaces, event horizons, 2+1+1 • the Kerr black hole • gravitational waves • spinors, Newman-Penrose formalism • black hole perturbation theory.

Goals: Understanding 3+1 and black hole perturbation theory; strengthen tools of differential geometry. These goals are to enhance students' mathematical/physical reasoning, critical and analytical reasoning.

## Evaluation

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| Grade type: | Letter grade A–F |
| Grade ranges: | (subject to change)<br>• A: 88% and up<br>• B: 75–87%<br>• C: 65–74%<br>• D: 55–64%<br>• F: <55% |
| Grade breakdown: | (subject to change)<br>• 66% Homework<br>• 34% Final |

The final will consist of two parts, on a single topic in general relativity: (i) an in-class presentation to the rest of the students (and any other interested parties); and (ii) a set of typed notes which are a review of the topic. The presentation should be about 15-20 minutes long, in the style of a seminar/lecture. The review paper must be a proper paper with a narrative of the topic. It is *not* simply copying a bunch of results out of the literature: it should give an explanation to a casual reader. Of course it must include a proper bibliography. Each student's topic for their final is up to them, but they have to run it by me first to check that it's an appropriate topic.

## Homework, tests, and final exam

Homework assignments will be announced in class, and they must be turned in at the beginning of class on the due date. Late homework will be penalized 20% per day (exceptions and extensions permitted with good cause). Homework must be easy to read: please clearly write down your name and the problem set number, do not use a red pen, write consistently on either one side or both sides of the paper and staple the pages together. The final exam will be open-book and open-notes, and a calculator will be permitted.

## Attendance

There is no strict attendance requirement, but you are strongly advised to attend class. Attendance has a strong correlation with performance. I recommend that you read the book sections in advance and come ready to participate. If you miss an exam or cannot turn in homework, please inform me beforehand and get a doctor's note if applicable. Absences from tests count as zeros, unless they are justified. If you must be absent during a test for a University sponsored event, you must discuss this with me before the test date.

## Academic Integrity

Violations of the University's policy of academic integrity will result in a failing grade and other disciplinary actions. A student with a documented case of plagiarism or cheating in this course will receive a failing grade for the course and may face disciplinary action by the University, including expulsion.

In particular, do not turn in problem set solutions copied from online or a solutions manual. Copying solutions does nothing to enhance your learning. If I see this then you will get an automatic 0 for the problem set. It if happens more than once I will report it to the chair of the department.

## Disability Access and Inclusion

The University of Mississippi is committed to the creation of inclusive learning environments for all students. If there are aspects of the instruction or design of this course that result in barriers to your full inclusion and participation, or to accurate assessment of your achievement, please contact the course instructor as soon as possible. Barriers may include, but are not necessarily limited to, timed exams and in-class assignments,

difficulty with the acquisition of lecture content, inaccessible web content, and the use of non-captioned or non-transcribed video and audio files. If you are approved through SDS, you must log in to your Rebel Access portal at https://sds.olemiss.edu to request approved accommodations. If you are NOT approved through SDS, you must contact Student Disability Services at 662-915-7128 so the office can: 1) determine your eligibility for accommodations, 2) disseminate to your instructors a Faculty Notification Letter, 3) facilitate the removal of barriers, and 4) ensure you have equal access to the same opportunities for success that are available to all students.

## Other

If a change in the syllabus becomes necessary during the semester, it will be discussed in class and then posted on the course website. The course website will also contain up-to-date information on the class schedule, homework assignments and complementary material.

## Schedule (subject to change)

To be filled in.

| | Tuesday | Thursday |
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| Week 01: 01/20–01/24 | Diff. geom. review | |
| Week 02: 01/27–01/31 | | |
| Week 03: 02/03–02/07 | | |
| Week 04: 02/10–02/14 | | |
| Week 05: 02/17–02/21 | | |
| Week 06: 02/24–02/28 | | |
| Week 07: 03/02–03/06 | | |
| Week 08: 03/09–03/13 | Spring break (no class) | |
| Week 09: 03/16–03/20 | | |
| Week 10: 03/23–03/27 | | |
| Week 11: 03/30–04/03 | | |
| Week 12: 04/06–04/10 | | |
| Week 13: 04/13–04/17 | | |
| Week 14: 04/20–04/24 | * | |
| Week 15: 04/27–05/01 | | |
| Finals: 05/04–05/08 | Final presentations | |

* = Leo has travel planned, another Prof. will give lecture (or reschedule)