General Relativity or "GR" (PHYS 325)

Spring 2026 v1.5

"*That one body may act upon another at a distance through a vacuum without the mediation of anything else, by and through which their action and force may be conveyed from one another, is to me so great an absurdity that, I believe, no man who has in philosophic matters a competent faculty of thinking could ever fall into it.*"
- Issac Newton in 1692 (letter to Bentley available from the Newton Project)

Welcome to GR! This course fixes Newton's "absurdity" by introducing Einstein's general relativity. We will spend the first bit of the course on curved space ("spacetime geometry") and the associated mathematics ("differential geometry"). After motivating the equations of motion, known as the Einstein's equations (or the field equations), we will concentrate on applications including the black holes, cosmology, and gravitational waves.

Contact Info:

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Office Hours: My office hours are Thursdays 2:30 - 5 PM. After class is also usually a good time for questions. If you cannot make these times, let's find a time when you and I are available.

Course Info:

The Phys 325 web site is here.

Course Structure:

The course will be in approximately traditional lecture-discussion format. We can take advantage of our smallish numbers to have plenty of spontaneous discussion, choose to have presentation if we wish, and determine which topics to focus on.

Textbooks:

There are many good GR texts. We will primarily use Schutz's *A first course in general relativity*, 3rd edition. I also draw from Jim Hartle's, *Gravity: An introduction to Einstein's General Relativity* and you may wish to have a copy of this too. On approximately the same level is Ohanian and Ruffini, *Gravitation and Spacetime*. The (now old) Mother Book is *Gravitation* by Misner, Thorne, and Wheeler. This weighty tome is fondly known as "MTW". There are now many, many introductions. I aim to work with material that is "upwards compatible". By upwards I have R. Wald's "General Relativity", a graduate level text, primarily in mind. Finally, I should add that Schutz has also written a fine introductory book on differential geometry.

Work:

We will have about 11 problem sets due on Thursdays at 11 PM via Gradescope (Code:7KBNVJ). We'll choose the form of the final: it could be a self-scheduled take-home final or the scheduled final (May 14 at 7 PM). I encourage you to work with others on the weekly problems. But when you do you must cite and with whom you worked and any other resources you use. Please write up your work with care. Each solution should be easy to read with the logic readily apparent.

If you find you are busy or unable to make the deadline for any reason you may take a 24 hour extension by simply emailing me before 11 PM Thursday stating that you will be taking an extension. (If there is an emergency then talk to me once it is over so we can work out a schedule for your work submission.)

The weighting of the semester grade will be solutions 65%, final 25%, and participation 10%.

Topics in brief:

- **Special Relativity**: (Schutz Chapters 1-3) the physics of SR, indices, 4-vectors, some tensors,
- **Curved Space**: (Schutz Chapters 5-7) tensor algebra, metric, covariant differentiation, Bianchi identities, curvature and physics, curvature and geometry
- **Einstein Equations**: (Schutz Chapter 8) The Theory, linear approximation
- **Black Holes**: (Schutz Chapter 11) Schwarzschild solution
- **Cosmology**: (Schutz Chapter 12)
- **Gravitational Waves**: (Schutz Chapter 9)