

GENERAL RELATIVITY

Physics 6553 / Astronomy 6509

Fall 2008

Instructor: Prof. Éanna Flanagan, 606 Space Sciences or 320 Newman Lab.
eef3@cornell.edu

Lectures: 01:25 - 02:40 Tuesdays and Thursdays, Rockefeller 128.

Office Hours: 3pm-5pm Wednesdays in 606 Space Sciences or after lectures.

TA: Jolyon Bloomfield is the TA for this course. His office is 619 Space Sciences and his email address is jkb84@cornell.edu. Jolyon will teach a section each week from 10:10-11:00am on Fridays in 301 Space Sciences.

Web Page: Information relevant to the course (handouts, problem sets, etc.) can be found on the web page
<http://www.astro.cornell.edu/~flanagan/ph6553/>
which can be accessed by following links from the physics department homepage.

Summary: This course together with Physics 6554 (offered in the spring) comprise a two-semester course on Einstein's general relativity and some of its important applications in astrophysics, cosmology and high energy theory. It is offered every two years. There is also an undergraduate-level introduction to general relativity, Physics 4445, which is offered every year. The first semester will focus primarily on the mathematical formalism and structure of the theory, while the second semester will concentrate on the applications and on advanced topics. Topics to be covered in the first semester include special relativity, differential geometry, the field equations, physics in curved spacetime, the Newtonian limit, linearized gravity, dragging of inertial frames, and black holes. Topics to be covered in the second semester will be some subset of the following list, depending in part on interest and demand: Gravitational collapse, cosmic censorship, astrophysics of black holes, gravitational waves, cosmology, action principle formulation, general relativity in higher dimensions, branes, and dimensional reduction, modified gravity theories, solar system tests, the post Newtonian approximation, global conservation laws, singularity theorems, the laws of black hole mechanics and thermodynamics, numerical formulations of the field equations, and the tetrad formalism.

Homework: Homework sets will be handed out once a week on Thursdays, and will be due the following Thursday. Except in special circumstances, late homeworks will be docked 10 percent for each day of lateness, and no credit will be given after the solutions have been handed out.

Homework assignments are an essential part of the course and should be taken very seriously. Solving problems is the most effective way of learning physics. Any effort put into it is an investment that will pay off later. It is legitimate, even desirable, for you to discuss the problems with other students, consult textbooks, the internet, or get advice from your TA or the instructor. However, the final work should be yours! You are expected to abide by the Cornell University Code of Academic Integrity.

Some of the homework problems will be required and some will be optional. The required problems will count towards the course grade. The optional problems are designed to challenge and stimulate you and will usually be more difficult than the required problems.

Exams: There will be a take home final exam. The course grade will be 50% based on the required homework problems, and 50% on the final exam. The final exam will be a take home final, available on the morning of Wednesday Dec 10, and due at 4pm on Monday Dec 15.

Prerequisites: I will assume that you have a strong foundation in undergraduate physics, particularly in special relativity, electromagnetism and classical mechanics (Lagrangians, Hamiltonians etc.). The mathematics background I will assume is multivariable calculus and differential equations. I will not assume that you have any courses in the specialized mathematics used in general relativity, differential geometry, which we will be covering in the first semester. If you have had math courses in differential geometry that would of course be helpful (although you may find our notation and emphasis quite different from those in math courses).

Textbook: The required textbook is *General Relativity*, by Robert M. Wald, published by University of Chicago Press, Chicago (1984), available in the bookstore. Wald's book is comprehensive, clear, detailed and precise. Its only drawback is that it is rather more mathematical in presentation and focus than most physics textbooks. No doubt some of you will find this appealing and others will find it off-putting. We will supplement Wald occasionally with assigned reading from other textbooks that have been placed on two hour reserve in the Physical Sciences Library. See a separate handout for a review of these and other useful books.