Physics 260 Syllabus

Professor: Steven Carlip

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Required text:

Sean Carroll, *Spacetime and Geometry*

Carroll's textbook gives a nice, reasonably broad introduction to general relativity, with a useful emphasis on cosmology (Carroll's own field) but with a bit less about experimental/observational tests than I would prefer. As always, though, different texts are better for different students. I will put several other books on reserve at Shields – see below.

Grading:

Homework	65%
Final paper	35%

Late homework will be accepted, but with a substantial deduction in the grade. (You need to keep up with the homework in order to understand the course!)

The required paper will be a short (7-10 page) paper treating a topic in theoretical or experimental gravitation in some depth. Papers are due Tuesday, December 11 by 5 pm. Late papers will *not* be accepted unless you have gotten permission in advance. Please tell me your topic well before you start writing; I can recommend references and readings, and suggest elements you might emphasize and warn you of others that might be too difficult.

Rough course plan (details will certainly change over the quarter)

I have a slightly unconventional – although increasingly popular – approach to teaching general relativity, in which we start with just enough math to look at observational predictions (for instance, gravitational deflection of light), *then* go back and learn the math required to write down and understand the Einstein field equations and to move on to more complicated topics. This "physics first" approach is the you're used to in other courses (you look at the electric field of a point charge before you learn Maxwell's equations), but is a little harder here, since you need to know *some* new math even to get started.

A very rough course outline is as follows. This will certainly change as we go.

Sept. 27	Introduction; equivalence principle, gravity as geometry
Oct. 2	Geodesics
Oct. 4-16	Using geodesics to test general relativity (light bending, orbits, Shapiro time delay, red shift)
Oct. 18	Introduction to differential geometry: manifolds, coordinates
Oct. 23 - 25	Vectors, tensors, metric; exterior calculus
Oct. 30- Nov. 6	Connection and covariant derivatives; curvature
Nov. 8	Einstein field equations and Einstein-Hilbert action principle
Nov. 13	Stress-energy tensor; deriving the equations of motion from the field equations
Nov. 15	The Newtonian limit, weak fields
Nov. 20	Weak fields, gravitational waves
Nov. 27	Black holes
Nov. 29 - Dec. 4	Cosmology
Dec. 6	Hamiltonian formulation

Books on reserve:

Different people learn better from different sources. If one book is too confusing, it sometimes helps to read a different author's approach, or to look at some worked out problems related to the point you're confused about. So in addition to the required class textbook, I am arranging to have several books placed on reserve at Shields Library. Assuming they can all be found, they are:

- Misner, Thorne, and Wheeler, *Gravitation* -- the "phone book," 1279 pages, with an "easy" track and a "hard" track. A great reference, though some people find Wheeler's writing style irritating
- Weinberg, *Gravitation and Cosmology* -- an oldish (1972) book with an old-fashioned but very clear approach to the mathematics of general relativity
- Schutz, *A First Course in General Relativity* -- a standard introductory textbook, with a special focus on gravitational radiation
- Hartle, *Gravity : An Introduction to Einstein's General Relativity* -- based on an advanced undergraduate course at Santa Barbara; a bit elementary for this course, but a good reference
- Wald, *General Relativity* -- a very nice but much more mathematical graduate textbook; it contains almost everything we'll do here, and a good deal more, but is heavy going

There is also a nice online textbook by Thomas Moore at pages.pomona.edu/~tmoore/grw/ that looks quite reasonable.

Some general advice:

The course assumes basic knowledge of classical mechanics (including Lagrangians and the variational principle), special relativity, vector analysis in flat space (gradient, divergence, Laplacian, etc.), and some basics of partial differential equations. If you have trouble with the background material, please see me – can point you toward supplemental reading, helpful Web sites, etc.

It would be a very good idea for you to read ahead – use the outline in this syllabus and be sure to read the relevant section of Carroll before it is the class topic. In my lectures, I will assume that you have done and understood the homework. If you get stuck on a point, come to office hours or email me to make an appointment. If you get stuck and you think you are not alone, though, tell me – it may mean that I should cover some issue in more detail in lecture.

Warning: homework and plagiarism

Your homework is expected to be your own work. I encourage you to discuss assignments with others, in person, online, or in study groups, but in the end you must each do the calculations yourself. If I receive homework that is obviously copied directly from someone else, I will find out what has happened, and may give you a 0 for the assignment. If it happens more than once, I will turn you in for plagiarism, which has some very serious penalties.

Your final paper *must* be your own work, with all sources properly cited. I have caught plagiarized papers in past (though not in this particular course); the consequences are extremely serious.