Physics 387N: Relativity Theory II (Spring 1998)

Schedule: Tue, Thu 12:30 - 2:00 PM --- RLM 5.116 --- Unique # 54055

Instructor: M.W. Choptuik
Office: RLM 9.208A --- **Office Hours**: Mon, Wed 10:00-11:30 and by appointment
Phone: 471-1541 --- **E-mail**: matt@infeld.ph.utexas.edu
Instructor's Home Page: http://wwwrel.ph.utexas.edu/Members/matt/welcome.html
Course Home Page:
http://wwwrel.ph.utexas.edu/Members/matt/Teaching/98Spring/Phy387N/Syllabus.html

Syllabus
News (No news yet!)
Course Notes
Project Handouts

Recommended Text: *General Relativity* by R. M. Wald, The University of Chicago Press, 1984.

Course Overview: This course will focus on providing students with an understanding of the formalisms and computational approaches which are currently of most use in studying strong-field aspects of classical general relativity. Lecture topics will include

- The Lagrangian formulation of general relativity and other classical field theories *(3)*
- The 3+1 (ADM/Hamiltonian) formulation of GR *(3)*
- The initial-value problem for GR *(2)*
- The evolution problem & coordinate (''gauge'') choices *(3)*
- Spherically symmetric collapse, black hole formation and critical phenomena *(7)*
- Black hole excision *(3)*
- Gravitational radiation *(3)*
- The initial-value problem for black holes *(2)*
- Class presentations *(2)*

(numbers in parentheses indicate roughly how many lectures will be devoted to each topic). Class work will consist primarily of three assigned projects and a term project, all of which will be performed in the context of 3-person teams, whose composition will be determined by the instructor. This work will have a *significant* computational component, and although computational techniques *will* be discussed in class from time to time, you may have to ''osmose'' certain skills from the instructor or other members of your team during non-class hours. Computational topics which will be encountered in the course include:

- Unix
- Fortran
- Solving ODEs using canned software.
- Solving linear systems using canned software.
- Solving non-linear equations using Newton's method.
- Solving time-dependent PDEs using finite-difference approximations (FDAs)

- Solving elliptic PDEs using FDAs and multi-grid techniques
- Scientific visualization using homegrown (such as ser) and commercial (such as Explorer) software.

As with all of the instructor's current computationally-oriented courses, the preferred course language is `Fortran`. Teams are not prohibited from using other languages, but the instructor will not necessarily provide the same level of support for those languages as for `Fortran`. Please follow the hyperlinks for some basic on-line material on the above topics.

Other References: As the course proceeds, a number of additional references will be used, and will be noted here.

Grades: Projects and Exam:

Course grades will be determined on the basis of performance on three assigned group projects, one term group project, and an open-book final exam, with the following weighting:

- Assigned projects: 50%
- Term projects: 40% *(35% write-up, 5% oral presentation)*
- Final Examination (open book): 10% *(Friday, May 15, 2:00-5:00 pm)*

As mentioned above, teams will consist of three (possibly four) students and will be chosen by the instructor. **Note:** Due to the nature of this course, the effort required for a CR (credit) is unlikely to be significantly different than the effort required for a good grade---students who have registered CR/NOCR for this course will probably want to take this into account.

Assigned projects

Assigned projects should be treated much like regular homework assignments except that team members *must* work together to complete the projects. For the most part, the instructor will leave it to the individual teams to ensure that a reasonable balance of work is achieved within each team. Unlike previous courses you may have taken from the instructor, late projects are unlikely to be accepted without an extremely good excuse.

Term projects

On or before **Thurs., March 12, 1998** (the last class day before spring break), each team must present the instructor with a one page summary of their term project, whose topic *must have previously been cleared with the instructor*. The instructor will be happy to suggest term-project topics, but also encourages the teams to pursue, if possible, specific computations of mutual interest. Term-project write-ups will be graded on the basis of a written report (estimated length 20-30 pages including figures and other results), and on an in-class oral presentation (roughly 30 minutes). The written report *must* be prepared in `LaTeX` (or `TeX`) and must be submitted to the instructor on or before the last class day, **Thurs., May 7, 1998** (*no exceptions!*) The oral presentation *per se* may be given by any number of group members, although *all* members should contribute to the preparation of the presentation. Presentation order will be chosen randomly.

Final exam

The final exam consists of the single question: *Write a short (1000-1500 word) essay on a subject in general relativity of your own choosing*. All topics must be cleared before the time of the final, which is tentatively **Friday, May 15, 2:00-5:00 pm**. Essays may be completed in the official exam period or at any previous time, but completed essays *must* be personally handed to the instructor during the official exam (i.e. you *must* officially show up for the exam). Again, if need be, the instructor will assist you in choosing a topic. Note that a particularly good time to complete the essay is early in the term before the other course work starts piling up! Essays need not be typed or word-processed, but must be legible.

Computer Access:

All students should have an account on the Physics Dept. public Unix systems located in the Graduate Computer Lab, RLM 3.118. More importantly, you will be given access to the Center for Relativity Unix machines. and will be expected to use these machines extensively for your group work. Note that most of these machines are in grad student and post-doc offices so you should not expect to be able to use any given machine on demand. However, I do not anticipate access to machines being particularly problematic in the context of completion of group work: if you do encounter such difficulties, contact the instructor immediately. Teams will also be provided with access to high-performance machines operated by the Texas Advanced Computing Center .

Miscellaneous Administrative Notes:

Please note the following cut-off dates. See the UT Austin Spring 1998 Course Schedule for more information.

- Feb 16, 1998: *Last day to drop a course without a possible academic penalty.*
- May 8, 1998: *Last day a graduate student may, with the approval of the instructor, the graduate adviser, and the graduate dean, drop a course.*

Syllabus

Due	Tuesday	Thursday
	January 20 Introduction (GR15 talk)	*January 22* Lagrangian GR
	January 27 Lagrangian GR	*January 29* Lagrangian GR
	February 3 3+1 GR	*February 5* 3+1 GR
	February 10 3+1 GR	*February 12* Initial Value Problem
	February 17 Initial Value Problem	*February 19* Evolution & Coordinates
	February 24 Evolution & Coordinates	*February 26* Evolution & Coordinates
	March 3 Spherical symmetry	*March 5* Spherical symmetry
	March 10 Collapse & BH formation	*March 12* Collapse & BH formation
	March 17 **Spring Break**	*March 19* **Spring Break**
	March 24 Critical Phenomena	*March 26* Critical Phenomena
	March 31 Critical Phenomena	*April 2* BH excision
	April 7 BH excision	*April 9* BH excision
	April 14 Gravitational radiation	*April 16* Gravitational radiation
	April 21 Gravitational radiation	*April 23* IVP for BHs
	April 28 IVP for BHs	*April 30* Group presentations
	May 5 Group presentations	*May 7* Presentations & Class Evaluation