

1. **Lectures:** Tu Th 9:30-10:45am Room 4208

2. **Instructor:** Prof. B. L. Hu, Phys 4209A, 405-6029, hub@physics.umd.edu. By appointment.

Reader/Tutor: Prof. Dieter Brill Phys 4202, 405-6027, brill@physics.umd.edu

3. **Texts:**

Track 1 is at an elementary (Junior-1st year graduate) level and Track 2 is at an intermediate (2nd – 3rd year graduate) level. This course is set at a level in-between to fulfill the dual needs of students seeking some general knowledge of general relativity and those who wish to continue doing research on this subject -- in which case they should also take Physics 776 offered in the Spring. (see brief announcement on page 3)

TRACK 1: * Items are worth owning. But wait till my comments in the first lecture

* James B. Hartle, *Gravity* (Addison-Wesley, San Francisco 2003).

QC173.6H38 2003 ISBN 0-8053-8662-9

-This new book will become a standard text for undergraduate physics and mathematics students

Bernard F. Schutz, *A First Course in General Relativity* (Cambridge, 1990)

QC173.55 ISBN 0 521 27703 5

TRACK 2:

*C. W. Misner. K. S. Thorne and John A. Wheeler, *Gravitation* (Freeman, San Francisco. 1973)

QC178.M57 ISBN 0 7167 0344 0 It has both Track 1 and Track 2 material

*S. Weinberg, *Gravitation and Cosmology* (Wiley, New York, 1972)

QC6.W47 ISBN 0 471 92567 5

Alan P. Lightman *et al*, *Problem Book in Relativity and Gravitation* (Princeton, 1973)

QC173.55P76 ISBN 0 681 08162-X

-This book is useful for assisting you to work out problems (but do work them out yourself!).

The following books may also be of interest:

E. F. Taylor and J. A. Wheeler, *Spacetime Physics: Introduction to Special Relativity* (Freeman, New York, 1992) QC17.65T37 ISBN 0 7167 2327 1 (for freshman/sophomore)

E. F. Taylor and J. A. Wheeler, *Exploring Black Holes: Introduction to General Relativity* (Freeman, New York, 2002) (for junior/senior)

P. J. E. Peebles, *Principles of Physical Cosmology* (Princeton, 1993)

QB981.P424 ISBN 0 691 01933 9 Intermediate (commensurate with our level)

Robert M. Wald, *General Relativity* (Chicago, 1984)

QC173.6.W35 ISBN 0 226 87033 2 Advanced (more suitable for Physics 776)

4. **Lectures, Homework and Exams**

Lectures: The lectures will be self-contained, at a level slightly higher than Hartle, closer to Track 1 of MTW. They may not adhere to any one book in its particular order or emphasis, but have their own logic and consistency. The best way is to follow closely the lectures and consult the corresponding topics discussed in any one of these books which suit your understanding best, followed by working out the assigned problems and try out extras in the problem book.

Homework: There will be weekly to biweekly assignments of homework problems to be handed in and graded. You are urged to work out the problems on your own, and discuss them with your classmates and with the tutor/reader, in that order. Don't waste this precious opportunity to learn by working things out on your own. Merely reading the solutions in the problem book, or worse yet, copying them to hand in, will severely hamper your exam performance and your understanding of the material (which is, after all, why you chose to take this course, I presume.)

Midterm Exam: Tentatively on Thursday Oct. 23, counts 100 points

Final Exam: on Tuesday, Dec 16 8:00am-10:00am. Counts 200 points.
University rule stipulates that you must take the final exam to get a course grade.

| | | |
|--|----------------|------------|
| <u>Course grade</u> is calculated based on : | Homework | 100 points |
| | 1 midterm exam | 100 points |
| | Final exam | 200 points |
| | Total | 400 points |

COURSE CONTENTS

Introduction Special Relativity: Spacetime approach, 4 vectors, geometric construction
Introduction to General Relativity: Gravitational redshift; Principle of Equivalence; Matter and spacetime curvature.

2. Curved Spacetime Principle of Covariance, coordinate transformations; Tensor Analysis, geometry of curved space. How matter moves in curved spacetimes: connection and Geodesic equations. How curvature of spacetime shows up: curvature and geodesic deviations.

3. Einstein's Equation: Vacuum solutions; Relativistic matter; Dynamics of spacetime and matter

4. Linearized Theory: Gravitational radiation; Einstein's equation for weak fields; Generation, propagation and detection of gravitational waves; Conservation of energy momentum and angular momentum

5. Relativistic Astrophysics: Spherically symmetric spacetimes; Schwarzschild metric; Stellar models and gravitational collapse; Trajectories around a compact object. Black holes

6. Relativistic Cosmology: Cosmological principles; Standard Model: Robertson-Walker metric and Friedmann solution; De Sitter spacetime and inflationary cosmology; The early universe.

Brief note from B L Hu about **Physics 776: Advanced Gravitation Theory** in Spring 2004

I have been assigned to teach this course in Spring 2004. This offers the opportunity to have a full-year 675-776 curriculum for students interested in pursuing Ph. D. research in gravitation theory and its related subjects, in particular, string theory, cosmology and gravitational wave astrophysics. All three subjects have been current 'hot topics', with rapid research developments, and new faculty hires here and elsewhere. With these developments there is increasing demand for good Ph. D. graduates with advanced training in gravitation theory. A new course (Physics 777) may soon be designed to satisfy these needs, but presently 776 is the only one which can serve this purpose.

The course content of Physics 776 for S'04 as I have planned it so far contains three parts:

-
- 1 Differential Geometry a la Cartan Calculus (moving frame approach)
 - 2 Gravitational Waves, gravitational perturbation theory, gravitational radiation reaction
 - 3 Cosmology of the early universe, including inflationary universe, and theoretical work related to recent experiments

They will be taught at the Track 2 level, joining with current research material from journals. Books used will be at the level of Wald, Peebles above, plus some recent titles in cosmology, e.g., P. Coles and F. Lucchin, *Cosmology: The origin and evolution of cosmic structures* Second Edition (Wiley, West Sussex, UK 2002) ISBN 0 471 48909 3

Note that **776 is designed such that students can take it more than once** to benefit from the changing current topics and the association with a different instructor.

If you have any request or suggestions please let me know.
