PHYS 399G General Relativity

Summer 2016

Meets May 31 - July 8
MTuWThF 1:00pm - 2:20pm
CHM 0124

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Course Description:

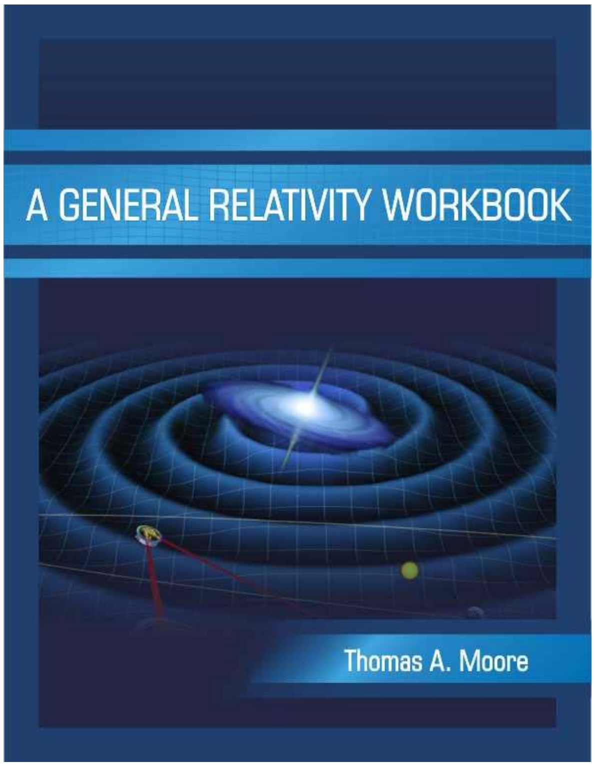
General Relativity is a theory of the class of physical phenomena encompassed by the term ***gravity***. It is generally considered the most accurate known theory of gravity. The theory describes gravity as the geometrical curvature of four-dimensional space-time, and this curvature is linked quantitatively to the energy-momentum distribution in the universe via the ***Einstein equation***. Having been for several decades the concern exclusively of mathematical physicists, in more recent times general relativity has been commanding the attention of experimental and computational scientists and even engineers, as for example in the design and operation of the ***Global Positioning System (GPS)***, and the mathematical foundation of the theory is now widely used in the burgeoning field of ***Transformation Optics***.

On the observational front, in recent years a vast array of scientific instruments, both space-based and earth-bound, has been providing ample observational data on extreme astrophysical phenomena, and the availability of this new empirical evidence has transformed general relativity from an abstract mathematical exercise into a research tool of great practical relevance. Such efforts have very recently culminated in the first direct detection of ***Gravitational Waves***, a phenomenon predicted by Einstein's theory which has no counterpart in Newtonian gravity.

The purpose of this course is to acquaint undergraduate students with the concepts and the mathematical apparatus underlying the theory, at a level where they would be capable of carrying out calculations to solve problems ranging from very simple to moderately difficult. However, this is emphatically ***not*** a mathematical physics course, and thus its focus will be constantly maintained on the physical interpretation of the intervening equations and their solutions, as well as on the physical phenomena to be described by the theory. Applications of the Einstein equation will be presented to circumstances in which its predictions produce small corrections to those of Newtonian gravity (e.g., ***precession of the perihelion***), as well as to cases in which there arise spectacular deviations between the two theories, including the anticipation of entirely new phenomena (e.g., ***gravitational waves)***. The latter circumstances involve extreme space-time curvatures (***black holes***), or very large scales (***the universe as a whole***). It is the aim of this course to illustrate the way in which General Relativity is utilized today at the forefront of scientific efforts to advance our understanding of the universe.

Required Textbook:

A General Relativity Workbook, *by Thomas A. Moore, (*published by *University Science Books* in 2013*) ISBN 978-1-891389-82-5*



Topics Covered:

Review of Special Relativity
Four-Vectors
Index Notation
Arbitrary Coordinates
Tensor Equations
Geodesics
The Absolute Gradient
Geodesic Deviation
The Riemann Tensor
The Stress-Energy Tensor
The Einstein Equation

Interpreting the Equation
The Schwarzschild Solution
The Schwarzschild Metric
Particle Orbits
Precession of the Perihelion
Photon Orbits
Gauge Freedom
Detecting Gravitational Waves
Gravitational Wave Energy

Homework and Exams:

- Homework will be assigned generally on a weekly basis. Although homework consultations are permitted, homework submissions are to be worked out independently and produced by the submitting student only
- A comprehensive take-home final exam will be given at the end of the course
- Students are responsible for all material covered in lectures. It is the students' responsibility to record accurately and to be aware of the specific lectures' contents.
- ***CLASS ATTENDANCE IS MANDATORY***

Assessment:

Homework	50% of final grade
Class Attendance	30% of final grade
Final exam	20% of final grade
TOTAL	100%

The final grade will be set at the end of the term after all work is completed. In assigning the final grade, I will be following the University of Maryland's grading policy, quoted below:

- A denotes excellent mastery of the subject and outstanding scholarship. (90-100)
- B denotes good mastery of the subject and good scholarship. (80-89)

- C denotes acceptable mastery of the subject and the usual achievement expected. (70-79)
- D denotes borderline understanding of the subject. It denotes marginal performance, and it does not represent satisfactory progress toward a degree. (60-69)
- F denotes failure to understand the subject and unsatisfactory performance. (< 60)

Tentative Course Schedule

PHYS 399G Summer 2016 --- Prof. Sergio Picozzi

Week Beginning:	*In-Class Activities:*
May 31	**Chapters 2-3-4**
Jun 6	**Chapters 5-6-8**
Jun 13	**Chapters 17-18-19**
Jun 20	**Chapters 20-21-22-23**
Jun 27	**Chapters 9-10-11-12**
Jul 5	**Chapters 30-31-32**