GENERAL RELATIVITY SYLLABUS
Fall 2023; 589 01W, Special Topics (Independent Study)

INSTRUCTOR: Dr. William Newton
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OFFICE HOURS: By appointment. We'll organize a time roughly every 2 weeks to meet.
TEXTBOOK: **"Gravity"** by **James Hartle**, Addison-Wesley, ISBN: 978-0805386622
ADDITIONAL MATERIAL Video lectures and Q&A sessions Lecture notes can be found on D2L organized by week to give you a structure to the class.

STUDENT LEARNING OUTCOMES:

- Students will demonstrate understanding of how the equivalence principle leads to a geometric understanding of gravity.
- Students will be able to apply geometrical methods to solve problems of Galilean and Special Relativity.
- Students will be able to use variational principles to derive the generalized form of Newton's first law of motion in curved space-time, and use that law to analyze the trajectories of particles in free fall in different spacetimes.
- Students will be able to perform basic tensor manipulations, algebra and differentiation.
- Students will be able to derive experimentally and observationally testable consequences from various spacetime metrics

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CLASS OVERVIEW

3 credit hours.
Einstein's principle of equivalence between physics in accelerating frames of reference and in local gravitational fields is the starting point of this course; we will demonstrate the relationship between the problem of getting rid of fictitious forces in accelerating frames by coordinate transformations and doing the same for gravitational forces. We then develop basic tensor algebra and calculus within the framework of special relativity, before introducing general coordinate transformations, the curvature tensor and the Einstein field equations. Tests and applications of the theory will include the effect on the GPS, the precession of the perihelion of Mercury, gravitational lensing, gravitational waves, black holes and neutron stars, and the Friedmann equations describing the expansion of the universe.
This is an independent study class, which means it will be largely self directed on the part of the student. A playlist of videos recorded when this class was taught during COVID are available: they contain most of the lectures and a number of office hours Q&A sessions. We will meet every two weeks to discuss progress.

GRADING

The overall class grade will be determined by the performance of the student in three categories:

- All the grade will be assessed based on homework problems: there will be one homework set every two weeks, due exactly two weeks after it is set; each will be worth around 12.5% of the class grade.(worth **50%** of the overall class grade). The homeworks will usually be set on Thursdays and due the following Thursday.

Final grades will be based on the standard scale:
• 90-100%: A • 80-89.99%: B • 70-79.99%: C • 60-69.99%: D • 59.99% & below : F

CLASS SCHEDULE:

A tentative schedule for the class:

Week	Subject
1	The equivalence principle and the link to geometry
2	Geometry of Galilean and Special Relativity
3	Special relativity: four vectors in spacetime
4	Newtonian gravity as geometry
5	Review and Test 1
6	Curved spacetime, Riemannian geometry and geodesics
7	The Schwarzchild solution and solar system tests of gravity
8	Tensors and covariant differentiation
9	Parallel transport and the Riemann curvature tensor
10	The Einstein equations
11	Review and Test 2
12	The linearized Einstein equations and gravitational waves
13	Black Holes
14	Rotating massive bodies in general relativity, relativistic stars
15	Cosmological models/Final

CLASS CONDUCT AND POLICIES:

1. **ADA Statement:** The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you have a disability requiring an accommodation, please contact:

Office of Student Disability Resources and Services
Texas A&M University-Commerce
Gee Library
Room 132
Phone (903) 886-5150 or (903) 886-5835
Fax (903) 468-8148
StudentDisabilityServices@tamuc.edu

2. **University policies**

- All students enrolled at the University shall follow the tenets of common decency and acceptable behavior conducive to a positive learning environment. (See Student's Guide Handbook, Policies and Procedures, Conduct). Rude or disruptive behavior will NOT be tolerated.
- Texas A&M University-Commerce does not tolerate plagiarism and other forms of academic dishonesty. Conduct that violates generally accepted standards of academic honesty is defined as academic dishonesty."Academic dishonesty" includes, but is not limited to, plagiarism (the appropriation or stealing of the ideas or words of another and passing them off as one's own), cheating on exams or other course assignments, collusion (the unauthorized collaboration with others in preparing course assignments), and abuse (destruction, defacing, or removal) of resource material.

3. **Attendance policy**.
Students are expected to arrive at each class on time and be present for all classes. Excused absences will be allowed at the discretion of the instructor provided that excessive absences do not become a problem. Valid reasons might include illness, school-sponsored events, court appearances and other emergencies. You should give your reason for absence or lateness **by email**. If you know ahead of time you will be late or absent, you must let me know by email **before the class** or the absence will not be excused. If the absence or lateness cannot be foreseen you should try and let me know by phone, and you must still email me with the reason **before the next class after the one you were late or absent for**. Written work/announcements/assignments/notes on material missed during absence or lateness must be made up. **Late homework** without valid excuse will be accepted with a points deduction which will increase for each class it is late after the due date.