

Physics 725: Special and General Relativity

Thornton 335, San Francisco State University

Fall 2011, MWF 3:10PM

Contact Information

Instructor: Andisheh Mahdavi

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Office Hours: Mondays 2-3PM; Tuesdays 12-1PM; sign up at the above website to get priority

Prerequisites

Physics 701 and 785 (may be taken concurrently), or permission of the instructor

Course Description

An introduction to Albert Einstein's theory of gravity. Covers tensor calculus, tensor formulations of special relativity, and the Einstein field equations. Applications include black holes, gravitational waves, and cosmology. Students are expected to use computer programs to solve for spacetimes and orbits.

Expected Student Learning Outcomes

At the end of the course, the successful student will understand mathematical representations of curved, four-dimensional spacetimes; will know how to solve the geodesic equations for motion within such spacetimes; will have a working knowledge of the deep connection between the metric describing such spacetimes and the Einstein field equations; will have a detailed understanding of the Schwarzschild and the Friedman-Robertson-Walker geometries.

Textbooks, Materials, and Other Requirements and Fees

- **Textbook:** James B. Hartle, *Gravity: An Introduction to Einstein's General Relativity*,
- **Computer and Internet Access:** Students should check email regularly for updates from the instructor.
- **Mathematica:** Mathematica, a computer program for symbolic calculus, will be used extensively throughout the course. It is installed on the machines in the Physics & Astronomy Computer Laboratory (Thornton 123), or may be purchased (student price: \$140) or rented (student rate: \$45/semester) for Windows, Mac, or Linux.

Grading Policy

Homework: 80%; Final exam: 20%. Late assignments will be marked down by 25% per day late.

Scale: A: 90-100%; A-: 80-90%; B+: 74-80%; B: 67-74%; B-: 60-67%; C+: 54-60%; C: 47-54%; C-: 40-47%; D+: 34-40%; D: 27-34%; D-: 20-27%

Students with Disabilities

Students with disabilities who need reasonable accommodations are encouraged to contact the instructor. The Disability Programs and Resource Center (DPRC) is available to facilitate the reasonable accommodations process.

The DPRC is located in the Student Service Building and can be reached by telephone (voice/TTY 415-338-2472) or by email (dprc@sfsu.edu)

Tentative Physics 725 Course Calendar

Week of	Topics	Chapters	Comments
8/22	Introduction to relativity; non-Euclidean geometries; the line element; map projections	1-2	
8/29	Newtonian gravity; the variational principle; Review of Lagrangian mechanics and Special Relativity	3-4	1st Homework Due 8/31;
9/5	Minkowski space; spacetime diagrams; Lorentz boosts; four vectors	4-5	No class 9/5; Drop Deadline is 9/6
9/12	special relativistic dynamics; relativistic doppler effect/beaming; equivalence principle; gravitational redshift	5-6	2nd Homework Due 9/14
9/19	Static/weak-field line element; curved spacetimes; wormholes; the warp drive metric	6-7	Add Deadline is 9/20
9/26	The geodesic equation and its solutions; Killing vectors; null geodesics	8	3rd Homework Due 9/28
10/3	Orbits in the Schwarzschild geometry; light ray orbits; gravitational lensing	9 and 12	
10/10	Schwarzschild black holes; Eddington-Finkelstein and Kruskal-Szekeres Coordinates	12-13	4th Homework due 10/12
10/17	Rotation and geodetic precession; Kerr black holes	14-15	CR/NC deadline on 10/18
10/24	Gravitational waves	16	5th Homework due 10/26
10/31	Mathematics of general relativity: tensor calculus; parallel transport and covariant derivatives;	20	
11/7	Riemann curvature; the equation of geodesic deviation	21	6th Homework Due 11/9; no class 11/11
11/14	The Einstein field equations in vacuum; conservation laws	21	
11/21	Fall break		
11/28	Energy-momentum-stress tensor; the full Einstein field equations; the Newtonian limit	22	7th Homework Due 11/30
12/5	Cosmology; Flat metrics; equations of state for matter and radiation; cosmological constant; Friedman-Robertson-Walker Metric	17-18	
12/12	Modern cosmology	19	last day of instruction 12/12; 8th Homework Due 12/14
12/19	Final exam 12/19 (sign up for 45 minute slot)		