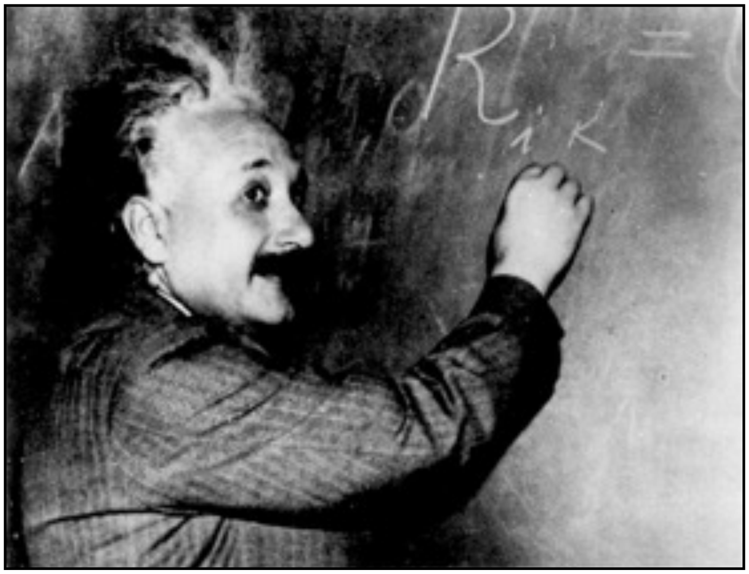
Relativity



Instructor: Prof. Deirdre Shoemaker
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Office Hours: Tuesday 3-4pm, Thursday 12-1:30pm

Teaching Assistant: Yu Qiu
Office Hours: Monday 3-4pm Boggs 1-38

Time: Tuesday/Thursday 1:35-2:55PM
Room: Howey S104
Prerequisites: Phys 3123 Classical Mechanics I

As undergraduates with an interest in physics, you have been pursuing an understanding of the fundamental theories governing nature as we know it. You have taken classes on classical and quantum mechanics, electromagnetism, thermal mechanics and perhaps atomic physics. You are now about to delve into the theories of special and general relativity which explain how gravity works in the universe. Gravitational physics is becoming increasingly important in astrophysics, cosmology and particle physics. This course of Special and General Relativity uses a `physics' first approach. Pioneered by Prof. James Hartle, this approach allows us to access the concepts of general relativity while delaying the full mathematical development of differential geometry. We will cover some of the mathematics intrinsic to general relativity, but only as needed to understand the important physical ramifications of the theory.

Textbook: *Gravity: An Introduction to Einstein's General Relativity* by James Hartle, with a corresponding website http://wps.aw.com/aw_hartle_gravity_1. The website is useful, containing links to Mathematica notebooks, web supplements, textbook errata, and links to related websites.

Course Objectives: After successfully completing this course, you should be able to

1. solve problems in curved spacetime using index notation, tensors and diagrams,
2. interpret gravitational phenomena using concepts from general relativity, and
3. recognize faulty scientific reasoning, your own and in the media.

Other useful books: "A First Course in General Relativity" by Bernard Schutz and "General Relativity Workbook" by Thomas Moore.

Course Topics: This course will briefly cover special relativity in order to introduce the key concepts that lead to a revolution in our understanding of space and time. The majority of the course will be spent on general relativity. We will cover, as time permits, spacetime curvature, metrics, geodesics, experimental verification of general relativity, black holes, Einstein equations and gravitational waves.

Academic Integrity: Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code.

Accommodations for Disabilities: If you have learning needs that require some adaptations for you to succeed in this course, please contact Disability Services (http://disabilityservices.gatech.edu). We can arrange to accommodate your learning needs based on their recommendations.

Grading Policy

Homework	15%
Exam 1	20%
Exam 2	20%
Exam 3	20%
Proposal for Final Project	5%
Progress Report	5%
Final Project	15%

Final Letter Grades

A	89.5-100%
B	79.5-89.4%
C	69.5-79.4%
D	59.5-69.4%
F	< 59.4%

Exam Policy: There will be 3 exams. All exams will be held during the regularly scheduled class time. See the schedule for the test dates. These exams will be in-class, closed books. I will provide a formula sheet before the test dates.

Homework Policy: Homework sets will be due Tuesday at the beginning of the class period. Unless special arrangements have been made with me before the assignment is due, we will use the following late assignment policy. Late assignments will be docked 5% if the assignment is turned in after class but before 5pm on the due date. Assignments will be penalized 10% for each late day, and 10% over a weekend. Turn in your late assignments to me personally, put them under my office door, or in my mailbox in the Physics Office in Howey. Working in a group can help in understanding the homework questions and is encouraged; however, **you must include the names of the group members** on the homework papers you turn in to me. No assignments will be accepted after solutions have been disclosed. The work you submit must be your own. Failure to do so will mean a 0% on that assignment and is a violation of the student honor code. Homework and exams will be graded using the following rubric

Completeness Points	Quality Points
4 – completed	4– correct solution
3 – missing explanations, steps	3 – minor errors
2 – missing major parts	2 - major errors
1, 0 – little or no effort	0 - incorrect solution

	Tuesday	Thursday
AUG	**23** Introduction What do space and time mean to Maxwell & Newton?	**20** Special Relativity: Ch. 4 What are the consequences of light as a universal constant?
	30 Special Relativity: Ch. 4 What measure do observes agree about? **Due**: HW1	**1** 4-vectors: Units Ch. 4 & Ch. 5 What is the difference between coordinate systems?
SEP	**6** Dynamics: Ch. 5 Can you catch up to a light beam? **Due**: HW2	**8** Index Notation: Supplement Why Bother?
	13 Tensors: Supplement Why do we need tenors? **Due**: HW3	**15** TEST Chapters 4,5 & Supplement on Index Notation
	20 Interstellar	**22** Interstellar
	27 Gravity as Geometry: Ch. 6 Gravity and constant acceleration are the same.	**29** Weak-field limit: Ch. 6 & 7 Gravity is not a force, but rather an inherent response to nature.
OCT	**4** Curved Spacetime/Warp Drive: Ch. 7 How would you define a vector on the surface of a potato? **Due**: HW4	**6** Geodesics Ch. 8 What is a straight line in curved spacetime?
	11 FALL BREAK	**13** TEST Chapters Supplement on Tensors, 6, 7 & 8
	18 Geodesic Eqn: Ch. 8 How are symmetric and conservation laws related? **Due**: HW5	**20** Schwarzschild: Ch. 9 What happens if you were to push the radius of the Sun to zero keeping the same mass? **Due:** Proposal
	25 Test Mass Orbits: Ch. 9 What kind of orbit is New Horizon's mission to Pluto? **Due**: HW6	**27** Particle Orbits: Ch. 9 Why is Mercury's precessional shift the largest of the planets?
NOV	**1** Photon Orbits: Ch. 9 How do the effective potentials of light and particles differ? **Due**: HW7	**3** Gravitational Waves: Ch. 16 What is LIGO?
	8 Gravitational Waves: Guest Lecture Dr. Clark GW150914 **Due**: HW8	**10** TEST Chapters 8, 9 & 16
	15 Black Holes: Ch. 12 Are they cosmic vacuum cleaners? **Due**: HW9	**17** Black Holes: Ch. 12 & 15 What is Cosmic Censorship? **Due:** Progress Report
	22 Kerr Black Holes How do we extract energy from a black hole? **Due**: HW10	**24 HOLIDAY**
	29 Geodesic Deviation: Ch. 21 How are tidal forces related to curvature?	**1** Curvature & Einstein Equations: Ch. 21 Spacetime geometry is dynamic
DEC	**6** Final Projects EXPO **Due:** Final Project	**8** NO CLASS