Special and General Relativity (PHZ 4601/5606 – Fall 2018)

Prof. Bernd A. Berg

Phones: 850-273-0001, 850-644-6246, e-mail: bberg at fsu dot edu

Office: 615 Keen

- Class: MWF 9:05–9:55 am at HCB 0209. First Class August 27.
- Office hours: Wednesdays 10:30-11:45 am and Thursdays 1:45-3:15 pm, and by appointment (send e-mail).
- Grader: Juan Mejia Marin, e-mail jjm17c at my dot fsu dot edu, Office hours Thursdays 5:15–7 pm at 614 Keen, and by appointment (send e-mail).
- Midterm (tentative): Friday October 12.
- Test on Homework (tentative): Friday November 30.
- **Final:** Thursday, December 11, 10 am – 12 pm at HCB 0209.

Required Text: Wolfgang Rindler, *Relativity, Special, General and Cosmological*, Second Edition, Oxford University Press, New York, 2006.

Overview and Goal

The course gives an introduction to the fundamentals of space, time and matter. As a systematic, mathematically rigorous treatment is beyond the scope of an undergraduate course, we intend in essence to learn by explaining (often omitting proofs) sections from the textbook by Rindler. **Bring the book to the lectures!** Under the title *Essential Relativity* the book started off as a one semester course for senior undergraduate students, but has since then been expanded to a two semester course. Therefore, we will have to omit about half of the material. For an overview see the tentative schedule at the end of this syllabus and compare it with the preface and the table of contents of the textbook.

After this course students should be able to explain the fundamental ideas of Special Relativity (SR) and General Relativity (GR) and master to solve by themselves standard problems to which the methods apply.

Homework and Classwork: Weekly homework assignments will be posted on the web, which have to be turned in **before** the beginning of the class indicated. After the class started problems can be still turned in at the end of the class, but 10% of the maximum possible points are taken off. After that solutions will only be accepted if there is a valid excuse. If you have to miss class communicate this by e-mail as early as possible. Each problem counts ten points unless stated otherwise.

Some problems will be solved in class. Therefore, you have to **bring paper, pencil(s) and a calculator to each class.** These (unannounced) Classwork assignments count towards the homework score. They are turned in during class and students missing such a class unexcused will get no credit. The decisive difference from the tests is that you can

talk to anyone during classwork, whereas during tests you may only ask the instructor for clarifications. Classwork is to some extent teamwork, while tests reflect individual skills.

On numerical work: When parameter values are given in a problem assignment, use them even when more accurate numbers are available. Round the final answer to the accuracy asked for with no rounding performed in-between. The reason for asking you to follow this procedure is that some problems are designed so that the difference between a wrong and a false solution path does show only up in the last digit asked for.

For full credit on home- and classwork you need only 90% of the maximally possible score. At the end of the semester 10% will be added with a maximum score cut at 100%. Additional homework problems will be assigned to the graduate students.

A standing assignment is to read the sections of the text as listed in the tentative schedule, which will be refined as we move along.

Prerequisites: General Physics PHY 2048, 2049 and PHY 3221 or equivalent courses. Calculus up to partial differentiation and vector analysis is required.

Grades will be based on 40% for homework and classwork, 15% for the midterm, 15% for a test on homeworks and 30% for the final. Anticipated dividing lines are: $A \geq 90\% > A^- \geq 85\% > B^+ \geq 80\% > B \geq 70\% > B^- \geq 65\% > C^+ \geq 60\% > C \geq 55\% > C^- \geq 50\% > D \geq 40\% > F$.

ADA: Students with disabilities should register with the Student Disability Resource Center and bring a letter to the instructor indicating their needs. Please do so during the first week of class.

Honor Code: Students are expected to uphold the Academic Honor Code published in the FSU Bulletin and the Student Handbook.

For more informations see the "Required Syllabus Statements" linked on the course website.

The Tentative Schedule follows on the next page. It will be updated when we proceed further.

Schedule (Tentative)		
Date	Topic	Rindler Chapters (Ch)
M Aug 27	Attendance, Syllabus. Introduction: Relativity.	Ch 1.1 (p.3) - 1.1 (p.4)
M Aug 29	Introduction: Newtonian Relativity.	Ch 1.2 (p.4) - 1.4 (p.7)
W Aug 29	Introduction: Maxwell equations and the Ether.	Ch 1.6 (p.9) - 1.7 (p.10)
F Aug 31	Introduction: Origins of SR.	Ch 1.9 (p.12) - 1.10 (p.15)
F Aug 31	Introduction: Einstein's Equivalence Principle (EP).	Ch 1.11 (p.15) - 1.16 (p.20)
M Sep 3	Labor Day - No Classes	
W Sep 5	Introduction: Gravitational frequency shift.	Ch 1.16 (p.24-27)
F Sep 7	Introduction: Gravitational frequency shift.	Ch 1.16 (p.24-27)
M Sep 10	Introduction: Curvature in 2D	Ch 1.16, p.27, Eq.(1.15)
W Sep 12	SR - Synchronization of Clocks	Ch 2.6
F Sep 14	2D Lorentz Transformations, Rapidity parameter	Supplement Notes, Ch 2
M Sep 17	Addition theorem for velocities	Supplement Notes, Ch 2
W Sep 19	2D Minkowski Space	Supplement Notes, Ch 2
F Sep 21	Energy - Momentum ($E = m\,c^2$)	Supplement Notes, Ch 2
M Sep 24		
M Sep 17	Space time and four Vectors	Chapter 5
F Sep 21	Four Tensors	Chapter 7
M Sep 24	Four Tensors	Chapter 7
W Sep 26	- Electrodynamics	Chapter 7
F Sep 28	GR (General Relativity) - Curved Spaces	Chapter 8
M Oct 1	GR - Static and stationary spacetimes	Chapter 9
W Oct 3	GR - Geodesics	Chapter 9, 10
F Oct 5	GR - Limit of Newton's gravity; Shapiro time delay	Chapter 9
M Oct 8	GR - Geodesics and differential geometry	Chapter 10
W Oct 10	Review for the Midterm	
F Oct 12	Midterm	
M Oct 15	GR - Differential geometry	Chapter 10
W Oct 17	GR - Covariant derivative	Chapter 10
F Oct 19	GR - Riemann curvature tensor	Chapter 10
M Oct 22	GR - Einstein's vacuum field equations	Chapter 10
W Oct 24	GR - Schwarzschild metric	Chapter 11
F Oct 26	GR - Schwarzschild metric coordinates and measurements	Chapter 11
M Oct 29	GR - Schwarzschild metric particle orbits	Chapter 11
W Oct 31	GR - Schwarzschild metric photon orbits	Chapter 11
F Nov 2	GR - Black holes	Chapter 12
M Nov 5	GR - Black holes	Chapter 12
W Nov 7	GR - Plane gravitational wave	Chapter 13
W Nov 9	GR - Plane gravitational wave	Chapter 13
M Nov 12	Veteran's Day - No Classes	
M Nov 14	GR - Full field equations	Chapter 14
F Dec 16	GR - Full field equations	Chapter 14
M Nov 19	GR - Linearization	Chapter 15
W Nov 21	Thanksgiving - No Classes	
F Nov 23	Thanksgiving - No Classes	
M Nov 26	GR - Linearization	Chapter 15
W Nov 28	GR - Linearization	Chapter 15
F Nov 30	Test on Homeworks	
M Dec 3	GR - Linearization	Chapter 15
W Dec 5	Evaluation Forms, Review for the Final	
F Dec 7	Review for the Final	
R Dec 13	Final 10 am ~~3~~ 12 pm	