Course Syllabus - PDF

Back

Course Content:

Required Texts: *Relativity, Gravitation, and Cosmology*, Ta-Pei Cheng, Oxford University Press, 2010.
An Introducton to Modern Cosmology, Andrew Liddle, Wiley, 2015.
Optional Text: *A Most Incomprehensible Thing: Notes Towards a Very Gentle Introduction to the Mathematics of Relativity*, P. Collier, 2017.

One of the greatest achievements in theoretical physics, only later to lead to exciting frontiers in experimental and computational physics, was Einstein's development of the General Theory of Relativity from 1907 to 1915. General Relativity is a theory of gravity and is necessary to understand recent advances at the forefront physics research, including black hole physics, the early universe, string theory, high energy physics and astrophysics.

The 2015 discovery of gravitational waves was recently recognized by the awarding of the 2017 Nobel prize in physics. Einstein predicted gravitational waves in his 1916-1918 papers based on General Relativity. Over the last century we have learned that the universe is expanding; our galaxy is one of billions and billions of other galaxies; the age of the universe is 13.80±0.04 billion years; gravitational waves exist; and, neutron stars were seen to collide.

This course is an introduction to special and general relativity as applied to the structure and evolution of the Universe. We will use space-time models to see general relativity as a metric theory of gravity and will explore examples of specific solutions (black holes, wormholes) and 'tests' of general relativity (bending of light). We will probe the nature and implications of cosmological models assuming large-scale homogeneity and isotropy. Topics may also include black holes, neutron stars, dark matter and energy, cosmic microwave background radiation, inflation, binary pulsars, gravitational waves, and the standard big bang model.
Prerequisites: Junior/Senior Standing. Preferably, students should have had a course in classical dynamics or modern physics and should have completed Calculus III. Additional mathematics and physics training is a plus. Interested students should contact Dr. Herman for additional information.

Student Learning Outcomes

Upon completion of this course, students will be able to

- Apply special relativity to problems involving time dilation, length contraction, and velocity addition.
- Work with four vectors and Lorentz transformations;
- State and apply the principle of equivalence;
- Define the metric tensor (& inverse), & interpret it;
- Calculate the special relativistic & Newtonian limits of general relativity;
- Discuss the tests of general relativity such as the precession of Mercury's perihelion, light bending, gravitational time dilation and redshift, and gravitational waves;
- Derive the Euler-Lagrange equations obtaining the geodesic equations and the Christoffel symbols;
- Write down the Schwarzschild and Robertson-Walker metrics; describe the meaning of all terms;
- Discuss metric singularities, event horizons and other properties of black holes;
- Discuss the meaning of Einstein's equation;
- Identify the key steps that lead to the recognition of the expanding Universe;
- Work with the Friedman equation to understand relativistic cosmology and basic cosmological models;
- Understand the physical implications of the cosmological expansion;
- Describe the physics and observational evidence for the Big Bang model;
- Explain why Einstein introduced the cosmological constant and the current evidence its value;
- Discuss the physics of the observed cosmic microwave background radiation;
- Understand the physics of the early universe, Big Bang Nucleosynthesis, and the universe's timeline;

Course Requirements:

Homework: Homework assignments will be collected on a regular basis and you will be told when the work is due. As doing homework is very important for learning the material in this course, it will count as 30% of your grade.
Papers/Projects: There are many interesting areas that might best be explored by individuals, or groups, outside the classroom. Such topics may arise in the course of the semester. You will be required to do at least two in-depth papers in this class. This will count 10% of your grade.
Exams and Grades: Exams and Grades: There will be a two 50 minute exams and a final exam. The exams will cover the basic material up to the date of the exam. The tentative dates for the exams are below.

Exam I	Feb 12
Exam II	Apr 9
Final	May 2, 11:30 AM

Your final grade will be based on the following:

Homework	25%
Papers/Projects	15%
Exams	40%
Final	20%

This syllabus is subject to change!

Homework Assignments

You should do as many problems as you can to become proficient in this class. However, you are required to turn in all of the assigned problems for grading on the due date. All work is expected to be neat, in order and with all work provided. The homework assignments are listed at the course website. [See below.]

Materials on the Web

More information will be posted on the web related to the topics we are studying. Links can be found with summaries to the material, study suggestions, homework assignments, etc. These will be accessible through the instructor's homepage at http://people.uncw.edu/hermanr/GRcosmo/.

Academic Honor Code:
All members of UNCW's community are expected to follow the academic Honor Code. Please read the UNCW Honor Code carefully (as covered in the UNCW Student Handbook). Academic dishonesty in any form will not be tolerated in this class. Please be especially familiar with UNCW's position on plagiarism as outlined in the UNCW Student Handbook. Plagiarism is a form of academic dishonesty in which you take someone else's ideas and represent them as your own.

Student Disabilities: UNCW Disability Services supplies information about disability law, documentation procedures and accommodations that can be found at http://uncw.edu/disability/. To obtain accommodations the student should first contact Disability Services and present their documentation to the coordinator for review and verification.

Campus Respect Compact. UNCW has recently instituted a Respect Compact to affirm our commitment to a civil community, characterized by mutual respect. That Compact will soon be affixed to the wall of each classroom and can be accessed at: http://uncw.edu/diversity/documents/ApprovedSeahawkRespectCompact8x10.08.09.pdf

Top

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