

COURSE SYLLABUS FORM

**American University of Beirut
Faculty of Arts and Sciences
Physics Department**

Course Number and Title: 309D, General Relativity and Cosmology

1. Course Learning Outcomes

The gravitational force is one of the four fundamental forces in nature. It is correctly described by Einstein's general theory of relativity. The student would learn to describe mathematically how matter curves space and how space tells matter how to move. A remarkable outcome of this course is the understanding cosmological models on the origin of the universe such as the big bang theory.

2. Resources Available to Students

This is a theoretical course, and the only tool available to the student is a mathematical framework based on few physical principles. There are many standard textbooks varying in the degree of mathematical rigor. We shall follow a book which proved to be accessible to students. The book is: |Gravitation and Cosmology by Steven Weinberg, John Wiley.

3. Grading Criteria

There will be two quizzes and a final with a weight distribution of 25%, 25% and 50%.

4. Schedule

Week 1: Historical introduction to non-Euclidean geometry.

Week 2: Special theory of relativity: Lorentz transformations, vectors and tensors, energy-momentum tensor, electromagnetic tensor.

Week 3: Principle of Equivalence, gravitational forces, metric and affine connection, Newtonian limit, signature of eigenvalues metric.

Week 4: Vectors and Tensors, tensor algebra, tensor densities, transformations of the affine connection, covariant differentiation, p-forms and exterior derivatives.

Week 5: Curvature tensor, parallel transport, algebraic properties of curvature tensor, Bianchi identities, geodesic deviation.

Week 6: Einstein-Hilbert action, Einstein's field equation, Cauchy problem, energy-momentum tensor of gravitation.

Week 7: Schwarzschild solution, Schwarzschild's singularity, Kruskal's extension, black holes. Deflection of light by sun.

Week 8: Gravitational radiation, weak field approximation, plane waves, generation of gravitational waves

Week 9: Killing vectors, maximally symmetric spaces, spaces with maximally symmetric subspaces.

Week 10: Robertson-Walker metric. Dynamics of a homogeneous isotropic universe.

Week 11: Solutions of Friedman's equations. Density and pressure of present universe. Open and closed universes.

Week 12: Models with cosmological constant, static Einstein model, deSitter model.

Week 13: Overview on advanced topics; Quantum effects. Gravity in higher dimensions.

5. Course Policy (if any)

Attendance is mandatory. If a student is absent for more than six lectures without a valid excuse, he must drop the course.