SSM
Scuola Superiore Meridionale

Course title:

Introduction to General Relativity

Duration [number of hours]**: 24**

PhD Program [MERC/MPS/SPACE]**: SPACE**

Name and Contact details of unit organizer(s):

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Course Description [max 150 words]**:**

The course intends to provide an introduction to General Relativity for which knowledge of the basic principles of Special Relativity, Electromagnetism and Classical Mechanics is required. It is aimed at graduates in engineering, physics and mathematics.

Syllabus [itemized list of course topics]**:**

1) Foundation of metric theories. Equivalence Principle. The covariant motion of particles. Geodesic motion. Christoffel's symbols. Weak gravitational fields. The physical meaning of the metric. The Mach principle.
2) Physical effects of the metric. Spectral line reddening. The synchronization of the clocks. Inertial forces.
3) Tensor Calculus. Tensor algebra and analysis. Covariant derivatives and parallel transport. The Riemann and Ricci tensors. The commutativity of second covariant derivatives and the Riemann tensor. The geodesic deviation.
4) The Einstein Field Equations. Properties of Newtonian gravitational fields. Deriving the field equations from conservation principles. The Einstein tensor. The energy-momentum tensor. The Hilbert-Einstein variational principle.
5) Solving the Einstein Equations. Techniques to achieve solutions. The Killing equation and isometries. The Schwarzschild solution. Physical applications of the Schwarzschild solution.
6) Classical tests of General Relativity. The planetary motion. The Mercury perihelion. The light bending. The gravitational redshift.
7) Gravitational waves. Metric perturbations. Polarization and helicity states. Radiation emission. Quadrupolar approximation. Sources of gravitational waves. Detection of gravitational waves.
8) Advanced topics. The Hamiltonian formalism. Extended Theories of Gravity. The teleparallel formulation.

Assessment [form of assessment, e.g., final written/oral exam, solutions of problems during the course, final project to be handed-in, etc.]**:**

Oral exam, solution of problems during the course, developing advanced topics.

Suggested reading and online resources:

1. "A Mathematical Journey to Relativity" W.G. Boskoff and S. Capozziello, Springer, Dordrecht 2020.
2. "Beyond Einstein Gravity", S. Capozziello and V. Faraoni, Springer, Dordrecht 2011.
3. "Introduzione alla Relatività Generale", S. Capozziello and M. Funaro, Liguori, Napoli 2005.
4. Notes provided by the Teacher.