

SPACE Area Courses (AA 2025-2026)

The courses are divided into Pillar courses (24 hours) and Monographic courses (12 hours).
The schedule is organized into the following blocks: Block 1: Nov 10 – Dec 19; Block 2: Jan 12 – Feb 20; Block 3: Mar 2 – Apr 17 ; Block 4: Apr 27 – Jun 5.

Pillar

Introduction to General Relativity

Lecturer: Prof. Capozziello

Period: 1st Block | Hours: 24

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.

- **Introduction to Astrophysics**

Module A: Prof. Risaliti

Module B: Prof. Napolitano

Period: 1st (Module A) and 2nd (Module B) Blocks | Hours: 24

The course covers the physical processes governing stars, including hydrostatic equilibrium, nuclear fusion, and radiation-matter interactions, followed by stellar evolution and the properties of white dwarfs and neutron stars. It also explores galaxy physics, focusing on classification, photometry, kinematics, and dynamics. Students will gain both observational and theoretical knowledge, providing a strong foundation for studying stellar and galactic evolution in astrophysics and cosmology

Introduction to Astroparticle Physics

Lecturer: Dr. Chianese and Dr. Saviano

Period: 2nd Block | Hours: 24

The course will address challenges in understanding the early and recent Universe, focusing on the connections between astrophysics and particle physics. It will review multi-messenger astrophysics, covering neutrinos, cosmic rays, and gamma rays, and present current knowledge of dark matter, including possible candidates like primordial black holes. Observational and experimental techniques will also be briefly explored.

Introduction to Space Engineering

Lecturer: Prof. Renga and Dr. Mungiguerra

Period: 3rd Block | Hours: 24

The course covers engineering challenges in space mission design and operations, focusing on the mission life-cycle and elements. It addresses three areas: GNSS, space research, and satellite reentry. GNSS principles, error sources, and advanced concepts are discussed. The course also highlights the role of microgravity in research and applications, and introduces hypersonic aerothermodynamics and spacecraft thermal protection during reentry.

- **Introduction to Cosmology**

Lecturer: Prof. Benetti and Dr. Conzinu

Period: 3th Block | Hours: 24

The course addresses the theoretical foundations of modern cosmology and the observational basis of the standard cosmological model. The main physical concepts and fundamental events in cosmic history are introduced, including the theory of inflation, the generation of cosmic microwave background anisotropies from primordial inhomogeneities, and the structure formation process.

- **Scientific Writing**

Prof. Russo

Period: 3rd – 4th Block | Hours: 24

The course offers an introduction to scientific publication in international journals, covering reasons for publishing, journal selection, writing style, ethics, editing, revisions, proofreading, and manuscript correspondence. It also includes the editorial structure of journals (Editor, associates, board members, publisher), the review process, review methods, and understanding bibliometric indices. Evaluation is based on exercises related to the course material.

- **Introduction to Space Systems**

Lecturer: Dr. Mungiguerra

Period: 4th Block | Hours: 24

The course presents scientific and technological aspects of systems for space flight. A general introduction to the history of space flight will be presented, including most recent missions and vehicles developments. Fundamentals of space missions, orbital dynamics, orbital maneuvers will be provided. The architecture of space launchers, including the concept of multi-stages will be presented. Moreover, the most relevant technologies for space propulsion systems will be described, including conventional and unconventional rockets and innovative solutions for atmospheric hypersonic flight.

Monographic

- **Complement of General Relativity**

Lecturer: Prof. Capozziello

Period: 1st Block | Hours: 12

In this course, alternatives and extensions to general relativity are examined to address its limitations at different energy scales. Particular focus is given to renormalizability and the cosmological constant problem. To modify general relativity, the Noether symmetry approach is introduced, along with its application to quantum cosmology. Finally, as a step toward a quantum framework for gravity, gauge theories and field theories in curved spacetime are explored.

- **Quantum Information Theory**

Lecturer: Prof. Hamma

Period: 2nd Block | Hours: 12

The course provides a modern formulation of quantum mechanics based on geometric and tomographic descriptions, aligning with current research. Also, we will explore advanced topics in quantum information theory, including the geometric description of quantum mechanics and statistical properties in Hilbert space, with a focus on typicality and equilibration.

- **Experimental methods in Astroparticle Physics**

Lecturer: Prof. Guarino

Period: 3rd Block | Hours: 12

This course covers modern experimental methods in astroparticle physics. It begins with particle detectors, then explores their integration into complex instruments. Techniques for cosmic ray physics, X-ray and gamma-ray astronomy, neutrino astronomy, dark matter searches, and gravitational wave detection are discussed. Numerous examples from astroparticle physics experiments illustrate these methods and their specific applications.

- **Observational Cosmology**

Lecturer: Prof. Benetti

Period: 4th Block | Hours: 12

This course builds on *Introduction to Cosmology* by computing observational predictions and comparing them with data. It introduces Markov Chain Monte Carlo (MCMC) methods for exploring cosmological parameters, the use of Boltzmann codes to generate theoretical predictions, and the analysis of results for constraining cosmological models.