

Guide to Study Plans

Master's Degree in Physics

A.Y. 2025/2026

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The selection of courses leading to the Master's Degree (LM) in Physics is an important process and serves as an initial direction for the area in which you will carry out your research or professional work. This guide aims to provide clarification on the possible choices offered by the Physics Degree Program in Pisa and the steps to implement those choices.

1 Glossary and Formal Steps

The process is divided into two distinct steps. As a first step, when enrolling in the LM program, you will need to formally choose one of five research macro-areas on the [Alice](#) portal, referred to below as *curricula*, or alternatively a general curriculum. This gives an initial indication of the exams to be taken to obtain the LM. However, this constraint can be largely modified through your **Individual Study Plan (PdSI)**, which must be submitted to the Department and represents the second and more significant phase of choosing your academic path. The PdSI is usually finalized only after becoming familiar with the courses and all the possible learning opportunities offered in the program¹

How to choose your PdSI. The wide range of course offerings is summarized through a series of recommended Study Plans (PdS), which help shape the Individual Study Plan (PdSI)—the precise set of exams a student intends to complete to earn the Master's Degree. The recommended PdS help guide this selection not only to fulfill the requirements for graduation in Physics but also to build a coherent and culturally complete study path for the subject area of interest.

Each recommended PdS includes some “mandatory” exams and a list of “recommended elective” exams that ensure the coherence and thematic consistency of the study path. Each course is associated with a *sector* identified by a label: FIS/xx. The first three letters indicate the scientific sector (FIS for Physics), and the following numbers specify the sub-sector according to the following classification:

- FIS/01 - Experimental Physics;

¹If you are receiving scholarships that depend on the number of mandatory exams, it is strongly recommended that you contact the teaching office to verify which exams are required to maintain your scholarship.

- FIS/02 - Theoretical Physics, Models, and Mathematical Methods;
- FIS/03 - Matter Physics;
- FIS/04 - Nuclear and Subnuclear Physics;
- FIS/05 - Astronomy and Astrophysics;
- FIS/06 - Earth System Physics;
- FIS/07 - Applied Physics;
- FIS/08 - Physics Education and History.

Some proposed exams may not fall within any FIS scientific sector but may instead belong to other sectors, such as Information Science (INF) or Mathematics (MAT).

Elective Courses. In every PdSI, 12 CFU can be chosen from all courses offered by the [Physics Degree Program](#), but also more generally from courses offered by other degree programs, including those at the Scuola Normale Superiore and the Scuola Sant’Anna. These elective CFUs must still form a coherent part of your PdSI, and in this sense the recommended PdS provide guidance, thanks to the dedicated list of “Recommended Elective Courses.” In addition, there are some courses within the Physics Program that address general topics and are therefore not tied to any particular Study Plan but may be selected within any of them. A short list of these courses can be found in Section 3.

Final Recommendations. Once you have decided which PdSI to follow, you must submit it for approval by the Degree Program Committee through the CAPS portal caps.df.unipi.it. The PdSI can be submitted at any time during the year and can be modified as many times as needed, but only the last approved version will be considered valid. If you choose to submit a free PdSI—i.e., one that does not belong to any of the recommended PdS listed later—you must follow the minimum rules listed in the relevant section and explain your choice with a comment in CAPS. The approval of a PdSI is not automatic, so especially if you submit a PdSI with modifications compared to the recommended PdS, it is important to submit the PdSI in CAPS before starting to take exams, to ensure that the selected courses form a suitable and approvable study path.

2 List of Recommended Study Plans

The list is in alphabetical order, while the Free PdSI appears at the end. At the end of each brief PdS description, the corresponding *curriculum* is indicated.

Astronomy and Astrophysics Develops investigative methods related to astrophysical and space topics, and deepens the connection between basic physics and observational evidence in astrophysics. (Curriculum Astronomy and Astrophysics)

Complex Systems A cross-disciplinary path that provides the tools to study complex systems, characterized by many interacting components and unpredictable, emergent behavior. (Curriculum General)

Data Analysis in Experimental Physics A study path to deepen aspects related to data analysis, including applications in experimental physics. (Curriculum General)

Fundamental Interactions Provides knowledge in the field of nuclear and subnuclear particle physics, gravitational waves, and cosmic-origin particles. (Curriculum Fundamental Interactions)

Medical Physics Focuses on the application of physics principles and methods to prevention, diagnosis, and treatment of human diseases. (Curriculum Medical Physics)

Phenomenology of Fundamental Interactions Provides both theoretical and experimental insights into fundamental interactions, bridging theoretical and experimental particle physics. (Curriculum General)

Physics for Cultural Heritage This study plan aims to train physicists capable of effectively interacting with Art Historians, Conservators, and Archaeologists to tackle complex interdisciplinary problems that can be addressed using physical research tools and methods. (Curriculum General)



Physics of Biosystems A study path to explore aspects of matter physics and complex systems applied to life sciences. (Curriculum Matter Physics)

Physics of Geofluids Dynamics and Solid Earth Provides theoretical and applied foundations for studying fundamental processes in geophysical fluids and solid Earth, with applications in earthquake physics, volcanology, and environmental physics. (Curriculum General)

Physics of Matter Dedicated to the theoretical and experimental study of matter states, both classical and quantum, and their interaction with electromagnetic fields. (Curriculum Matter Physics)

Physics of the Universe Equips students to study cosmic phenomena using an interdisciplinary approach— both theoretical and experimental—based on observing various cosmic signals like gravitational waves, electromagnetic radiation, and astroparticles. Takes advantage of proximity to the European Gravitational Observatory (EGO) and ongoing research with the Advanced VIRGO gravitational wave detector. (Curriculum General)

Plasma Physics A path to acquire foundational knowledge of plasma physics processes, focusing on both space plasmas and fusion. (Curriculum Matter Physics)

Quantum Computing and Technologies Provides skills in the field of Quantum Computing, both theoretical and experimental. (Curriculum General)

Theoretical Physics Provides expertise in theoretical physics, covering quantum field theories, fundamental interactions, gravitation theory, statistical and condensed matter physics, and nuclear interactions. (Curriculum Theoretical Physics)

Theory of Quantum Materials Develops theoretical and computational methods for studying new materials. (Curriculum General)

Free Study Plan Allows construction of an Individual Study Plan that does not conform to any of the recommended PdS listed above.

3 Elective Courses Not Specific to Any Particular Study Plan

[408BB] PHYSICS OF SOUND	FIS/07	06 CFU
[092BB] PHYSICS OF SURFACES AND INTERFACES	FIS/03	03 CFU
[357BB] LASER-PLASMA ACCELERATORS	FIS/03	06 CFU
[428BB] NUCLEAR WEAPONS, DISARMAMENT AND NON-PROLIFERATION	FIS/04	06 CFU
[407BB] CURRENT TRENDS IN QUANTUM MATTER	FIS/03	03 CFU

4 Details of the Recommended Study Plans

Please note that newly introduced courses may not immediately have working links in the Course Catalogue. To address this, provisional course pages have been created to briefly describe these courses until they are officially added to the catalog. In all the recommended study plans below, the following aspects should be taken into account:

- **Prerequisites.** When choosing exams for your Individual Study Plan, we recommend checking the course content and prerequisites on the degree website using the provided course links.
- **Courses also offered in the Bachelor's program.** Some courses are also available at the undergraduate level. To include them in your PdSI, you must attach an exam transcript or, if applicable, declare that you are transferring from another university. The relevant courses are:
 - ⇒ [368BB] GENERAL ASTROPHYSICS,
 - ⇒ [0024B] FLUID DYNAMICS
- **Courses with non-standard semesters.** Courses shared with or borrowed from the PhD program, as well as some SNS courses, may be scheduled outside the standard semesters (I or II). We suggest contacting the instructors for more information. Be especially mindful of the scheduling, as these courses may not fit neatly into the typical semester structure. The UniPi courses affected include:
 - ⇒ [404BB] NONPERTURBATIVE APPROACHES TO QUANTUM FIELD THEORIES S,
 - ⇒ [358BB] NONPERTURBATIVE APPROACHES TO QUANTUM FIELD THEORIES,
 - ⇒ [382BB] QUANTUM LIQUIDS,
 - ⇒ [0041B] STATISTICAL ANALYSIS LABORATORY.
- **Non-FIS courses.** In most PdS, this is not a limiting factor, but it is never allowed to include more than 24 CFU of courses from scientific-disciplinary sectors other than FIS/xx. When relevant, this rule will be explicitly stated in the PdS.
- **Number of CFU.** Each PdSI must include courses totaling at least 75 CFU, which, together with the 45 CFU for the final thesis, add up to the required 120 CFU. Plans significantly exceeding 120 CFU will be discouraged and, if accepted, will require passing *all* the listed exams.
- **Suggested tracks.** Given the broad range of offerings, many course sheets include examples of effective academic paths based on previously submitted PdSI.
- **Modifying your PdSI.** Although it is possible to modify your PdSI at any time, it is strongly advised to define a clear direction as early as possible. You are expected to pass all exams listed in your *most recently* approved PdSI.

The details of each recommended PdS are available in the following sections. For any questions or issues regarding this guide, do not hesitate to contact the Teaching Office (segr.dida@unipi.it) or the Program Chair (stefano.rodaro@unipi.it).

ASTRONOMY AND ASTROPHYSICS

Insegnamenti vincolati del PdS

minimo

57 CFU

Gruppo obbligatori (tutti i seguenti)

I s	[226BB] ASTROPHYSICAL PROCESSES	FIS/05	09 CFU
A	[0010B] ASTROPHYSICS AND MULTIMESSENGER LABORATORY	FIS/01	12 CFU
II s	[369BB] EXTRAGALACTIC ASTROPHYSICS AND COSMOLOGY	FIS/05	09 CFU
II s	[211BB] STELLAR PHYSICS	FIS/05	09 CFU

Gruppo fisica teorica (almeno uno dei seguenti)

I s	[228BB] GENERAL RELATIVITY	FIS/02	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo microfisica e struttura della materia (almeno uno dei seguenti)

I s	[206BB] NUCLEAR PHYSICS	FIS/04	09 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU

Insegnamenti a scelta consigliati

massimo

18 CFU

(almeno 6CFU dai seguenti o dai vincolati non scelti)

I s	[0013B] ADVANCED TECHNOLOGIES FOR GROUND-BASED ASTROPHYSICS: FROM MICROWAVES TO VISIBLE LIGHT	FIS/05	06 CFU
I s	[306BB] EXPERIMENTAL METHODS FOR ASTROPARTICLE PHYSICS	FIS/01	09 CFU
I s	[307BB] EXPERIMENTAL METHODS FOR ASTROPARTICLE PHYSICS S	FIS/01	06 CFU
I s	[0024B] FLUID DYNAMICS	FIS/03	06 CFU
I s	[0011B] MULTIMESSENGER AND HIGH-ENERGY ASTROPHYSICS	FIS/05	06 CFU
I s	[0012B] PHYSICS OF STAR FORMATION	FIS/05	06 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
II s	[214BB] ADVANCED QUANTUM FIELD THEORY	FIS/02	09 CFU
II s	[192BB] ASTROPARTICLE PHYSICS	FIS/05	09 CFU
II s	[063BB] ASTROPARTICLE PHYSICS S	FIS/05	06 CFU
II s	[091BB] COMPACT STAR PHYSICS S	FIS/04	06 CFU
II s	[274BB] COSMOLOGY OF THE EARLY UNIVERSE	FIS/05	09 CFU
II s	[275BB] COSMOLOGY OF THE EARLY UNIVERSE S	FIS/05	06 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
II s	[170BB] EXOPLANETARY SYSTEMS	FIS/05	06 CFU
II s	[140BB] GRAVITATION THEORIES S	FIS/02	06 CFU
II s	[251BB] GRAVITATION THEORY	FIS/02	09 CFU
II s	[0046B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES	FIS/01	09 CFU
II s	[0047B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES S	FIS/01	06 CFU
II s	[0016B] THEORY OF NUCLEAR INTERACTION S	FIS/02	06 CFU
A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU

Additional Notes

Within some possible thematic tracks in Astrophysics, the following elective courses are suggested.

Stellar Physics Track:

- [091BB] Compact star physics S (6 CFU)
- [0012B] Physics of star formation (6 CFU)

Galactic Astrophysics and Cosmology Track:

- [0012B] Physics of star formation (6 CFU)
- [257BB] Cosmology of the early universe S (6 CFU)
- [228BB] General relativity (9 CFU)

Gravitational Waves and Compact Objects Track:

- [256BB] Physics of gravitational waves S (6 CFU)
- [091BB] Compact star physics S (6 CFU)
- [228BB] General relativity (9 CFU)

Planetary Physics Track:

- [0012B] Physics of star formation (6 CFU)
- [170BB] Exoplanetary systems (6 CFU)

Observational Astronomy Track:

- [0013B] Advanced technologies for ground-based astrophysics (6 CFU)
- [0011B] Multimessenger and high-energy astrophysics (6 CFU)

COMPLEX SYSTEMS

Insegnamenti vincolati del PdS

minimo

33 CFU

Gruppo obbligatori (tutti i seguenti)

I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo fisica sperimentale (almeno uno dei seguenti)

A	[403BB] BIO-SYSTEMS LAB	FIS/01	15 CFU
A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU
I s	[360BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS	FIS/01	09 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU

Gruppo astrofisica (almeno uno dei seguenti)

II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
II s	[211BB] STELLAR PHYSICS	FIS/05	09 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

42 CFU

(include gli insegnamenti vincolati non scelti e quelli a seguire)

I s	[178EE] BIOINFORMATICS	INF/01	03 CFU
I s	[878II] DATA MINING AND MACHINE LEARNING	ING-INF/05	12 CFU
I s	[309BB] DISORDERED SYSTEMS OUT OF EQUILIBRIUM	FIS/03	09 CFU
I s	[0024B] FLUID DYNAMICS	FIS/03	06 CFU
I s	[783AA] GEOSPATIAL ANALYTICS	INF/01	06 CFU
I s	[399BB] INTRODUCTION TO MOLECULAR BIOPHYSICS	FIS/03	06 CFU
I s	[654AA] MACHINE LEARNING	INF/01	09 CFU
I s	[387BB] PHYSICS OF BIOSYSTEMS	FIS/03	09 CFU
I s	[376BB] QUANTUM COMPUTING AND TECHNOLOGIES	FIS/03	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
II s	[0005B] 3D AND 4D NANOMATERIALS AND DEVICES	FIS/03	09 CFU
II s	[214BB] ADVANCED QUANTUM FIELD THEORY	FIS/02	09 CFU
II s	[273BB] BIOPHYSICAL MODELLING OF COMPLEX SYSTEMS	FIS/03	06 CFU
II s	[279BB] COMPLEX SYSTEMS - NEURAL DYNAMICS	FIS/03	09 CFU
II s	[513LL] COMPUTATIONAL LINGUISTICS II	L-LIN/01	06 CFU
II s	[674AA] COMPUTATIONAL NEUROSCIENCE	INF/01	06 CFU
II s	[699AA] DATA ANALYSIS	MAT/06	06 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
II s	[PHD-DCS] DYNAMICS OF COMPLEX SYSTEMS	MAT/07	06 CFU
II s	[288DD] EARTHQUAKE SEISMOLOGY	GEO/10	06 CFU
II s	[211AA] GAME THEORY	MAT/09	06 CFU
II s	[375BB] LARGE SCALE PHYSICAL OCEANOGRAPHY	FIS/03	09 CFU
II s	[0021B] MICROBIOROBOTICS	FIS/03	06 CFU
II s	[0020B] NEUROENGINEERING	FIS/03	06 CFU
II s	[322BB] NONLINEAR DYNAMICS	FIS/03	09 CFU
II s	[0028B] PHYSICS OF THE ATMOSPHERE AND PRINCIPLES OF METEOROLOGY	FIS/07	06 CFU
II s	[0019B] QUANTUM MACHINE LEARNING	FIS/03	03 CFU
II s	[425BB] QUANTUM THERMODYNAMICS	FIS/03	06 CFU
II s	[668AA] SOCIAL NETWORK ANALYSIS	INF/01	06 CFU
II s	[628PP] STATISTICS FOR DATA SCIENCE	SECS-S/01	09 CFU
A	[420AA] DATA MINING	INF/01	12 CFU
A	[676AA] DATA MINING: FUNDAMENTALS	INF/01	06 CFU
A	[SNS-MTT] MARKETS, TRADING AND TECHNOLOGY	FIS/03	03 CFU
A	[SNS-MMQF] MATHEMATICAL MODELS FOR QUANTITATIVE FINANCE	FIS/03	06 CFU
A	[SNS-QF] QUANTITATIVE FINANCE	FIS/03	06 CFU
A	[SNS-SMLM] STATISTICAL AND MACHINE LEARNING MODELS FOR TIME SERIES ANALYSIS	FIS/03	06 CFU

Additional Notes

- at least 18 CFU out of the 42 elective CFU must be from FIS scientific-disciplinary sectors;
- the course [878II] DATA MINING AND MACHINE LEARNING overlaps in content with [676AA] DATA MINING: FUNDAMENTALS and [420AA] DATA MINING. It is therefore necessary to submit a study plan indicating how many CFU will be credited if you plan to take more than one of these courses;
- in particular, the course [676AA] DATA MINING: FUNDAMENTALS is the first part of [420AA] DATA MINING, so they cannot both be taken;



- the course [676AA] DATA MINING: FUNDAMENTALS is part of a limited-enrollment Master's Program: attendance is subject to available spots and must be agreed upon with the instructor at the beginning of the course;
- in the "Experimental Physics" group, it is possible to fulfill the requirement with the pair "Computing methods for experimental physics and data analysis S" (6 CFU) + "Numerical methods for physics S" (6 CFU). In this case, both exams must be completed.

Based on previous study paths chosen by students who followed a specific direction within the field of complex systems, the following courses are typically found in their respective study plans:

FINANCE Path:

- [SNS-MTT] Markets, trading and technologies
- [SNS-MMQF] Mathematical models for quantitative finance: market microstructure, networks, and systemic risk
- [SNS-QF] Quantitative finance
- [SNS-SMLM] Statistical and machine learning models for time series analysis
- [668A] Social network analysis

NEURONS and BRAIN Path:

- [279BB] Complex systems - neural dynamics
- [674AA] Computational neuroscience
- [326BB] Computational physics laboratory (including the module Nonlinear physics methods and neuroscience)
- [0020B] Neuroengineering
- [322BB] Nonlinear dynamics
- [420AA] Data mining

ACTIVE MATTER Path:

- [309BB] Disordered systems out of equilibrium
- [0021B] Microbiorobotics
- [273BB] Biophysical modelling of complex systems
- [0024B] Fluid dynamics
- [399BB] Introduction to molecular biophysics
- [375BB] Large scale physical oceanography
- [387BB] Physics of biosystems

EARTH SYSTEM Path:

- [0024B] Fluid dynamics
- [375BB] Large scale physical oceanography
- [0028B] Physics of the atmosphere and principles of meteorology
- [288DD] Earthquake seismology
- [353BB] Plasma physics

CHAOS and DYNAMIC SYSTEMS Path:

- [PHD-DCS] Dynamics of complex systems
- [326BB] Computational physics laboratory (including the module Nonlinear physics methods and neuroscience)
- [322BB] Nonlinear dynamics
- [425BB] Quantum thermodynamics

COMPLEXITY and NETWORKS Path:

- [420AA] Data mining
- [783AA] Geospatial analytics
- [654AA] Machine learning
- [668AA] Social network analysis

DATA ANALYSIS IN EXPERIMENTAL PHYSICS

Insegnamenti vincolati del PdS

minimo

48 CFU

Gruppo obbligatori (tutti i seguenti)

I s	[360BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS	FIS/01	09 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU

(almeno uno dei seguenti)

II s	[380BB] INSTRUMENTATION FOR FUNDAMENTAL INTERACTIONS PHYSICS	FIS/01	09 CFU
A	[414BB] LABORATORIO INTERAZIONI FONDAMENTALI S	FIS/01	09 CFU
II s	[0047B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES S	FIS/01	06 CFU
II s	[0007B] QUANTUM TECHNOLOGIES FOR FUNDAMENTAL INTERACTION PHYSICS	FIS/01	09 CFU

Gruppo fisica teorica (almeno uno dei seguenti)

I s	[228BB] GENERAL RELATIVITY	FIS/02	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo microfisica e struttura della materia (almeno uno dei seguenti)

II s	[217BB] ACCELERATOR PHYSICS	FIS/04	09 CFU
I s	[305BB] FUNDAMENTAL INTERACTIONS	FIS/04	09 CFU
I s	[206BB] NUCLEAR PHYSICS	FIS/04	09 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
I s	[204BB] SOLID STATE PHYSICS	FIS/03	09 CFU

Gruppo astrofisica (almeno uno dei seguenti)

II s	[063BB] ASTROPARTICLE PHYSICS S	FIS/05	06 CFU
II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
II s	[274BB] COSMOLOGY OF THE EARLY UNIVERSE	FIS/05	09 CFU
II s	[369BB] EXTRAGALACTIC ASTROPHYSICS AND COSMOLOGY	FIS/05	09 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

27 CFU

(almeno 9CFU dai seguenti o dai vincolati non scelti)

I s	[878II] DATA MINING AND MACHINE LEARNING	ING-INF/05	12 CFU
I s	[654AA] MACHINE LEARNING	INF/01	09 CFU
I s	[376BB] QUANTUM COMPUTING AND TECHNOLOGIES	FIS/03	09 CFU
I s	[338BB] SIGNAL PROCESSING FOR PHYSICS	FIS/01	06 CFU
II s	[699AA] DATA ANALYSIS	MAT/06	06 CFU
II s	[185BB] MONTECARLO METHODS IN EXPERIMENTAL PHYSICS	FIS/01	06 CFU
II s	[668AA] SOCIAL NETWORK ANALYSIS	INF/01	06 CFU
A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU
A	[420AA] DATA MINING	INF/01	12 CFU
A	[676AA] DATA MINING: FUNDAMENTALS	INF/01	06 CFU

Additional Notes

- The course [878II] DATA MINING AND MACHINE LEARNING has content overlap with [676AA] DATA MINING: FUNDAMENTALS and [420AA] DATA MINING. Therefore, it is necessary to submit a study plan specifying how many CFU will be counted if you intend to take more than one of these courses;
- In particular, the course [676AA] DATA MINING: FUNDAMENTALS is the first part of [420AA] DATA MINING, so they cannot both be chosen;
- The course [676AA] DATA MINING: FUNDAMENTALS is offered in a limited-enrollment Master's program: the possibility to attend depends on the availability of free slots and must be agreed upon with the instructor at the start of the course.

FUNDAMENTAL INTERACTIONS

Insegnamenti vincolati del PdS

minimo

54 CFU

Gruppo obbligatori (tutti i seguenti)

I s	[305BB] FUNDAMENTAL INTERACTIONS	FIS/04	09 CFU
A	[413BB] FUNDAMENTAL INTERACTIONS LABORATORY	FIS/01	15 CFU

Gruppo fisica sperimentale, nucleare e subnucleare (gruppo 1) (almeno uno dei seguenti)

II s	[373BB] PARTICLE PHYSICS S	FIS/04	06 CFU
II s	[0047B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES S	FIS/01	06 CFU
II s	[0007B] QUANTUM TECHNOLOGIES FOR FUNDAMENTAL INTERACTION PHYSICS	FIS/01	09 CFU

Insegnamenti fisica sperimentale, nucleare e subnucleare (gruppo 2) (almeno uno dei seguenti)

II s	[217BB] ACCELERATOR PHYSICS	FIS/04	09 CFU
I s	[360BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS	FIS/01	09 CFU
II s	[380BB] INSTRUMENTATION FOR FUNDAMENTAL INTERACTIONS PHYSICS	FIS/01	09 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU

Gruppo fisica teorica (almeno uno dei seguenti)

I s	[228BB] GENERAL RELATIVITY	FIS/02	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU

Gruppo astrofisica (almeno uno dei seguenti)

II s	[063BB] ASTROPARTICLE PHYSICS S	FIS/05	06 CFU
II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
II s	[275BB] COSMOLOGY OF THE EARLY UNIVERSE S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

21 CFU

(almeno 9CFU dai seguenti o dai vincolati non scelti)

I s	[306BB] EXPERIMENTAL METHODS FOR ASTROPARTICLE PHYSICS	FIS/01	09 CFU
I s	[304BB] FUNDAMENTALS OF LIGHT MATTER INTERACTION	FIS/03	09 CFU
I s	[385BB] INTRODUCTION TO NEUTRINO PHYSICS	FIS/04	03 CFU
I s	[206BB] NUCLEAR PHYSICS	FIS/04	09 CFU
I s	[427BB] PARTICLE DARK MATTER	FIS/01	06 CFU
I s	[1095I] RADIATION PROTECTION	ING-IND/20	06 CFU
I s	[338BB] SIGNAL PROCESSING FOR PHYSICS	FIS/01	06 CFU
I s	[204BB] SOLID STATE PHYSICS	FIS/03	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU
II s	[214BB] ADVANCED QUANTUM FIELD THEORY	FIS/02	09 CFU
II s	[0008B] BIOPHYSICS OF EFLASH THERAPY	FIS/07	09 CFU
II s	[0035B] DESIGN OF DIGITAL SYSTEMS FOR RADIATION DETECTION	FIS/07	06 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
II s	[308BB] DISCRETE SYMMETRIES	FIS/04	06 CFU
II s	[198BB] DOSIMETRY	FIS/07	06 CFU
II s	[080BB] ELECTRONICS AND SENSORS	FIS/07	06 CFU
II s	[0004B] FLEXIBLE AND NANO-ELECTRONICS	FIS/03	09 CFU
II s	[201BB] HADRON COLLIDER PHYSICS	FIS/04	09 CFU
II s	[371BB] HADRON COLLIDER PHYSICS S	FIS/04	06 CFU
II s	[185BB] MONTECARLO METHODS IN EXPERIMENTAL PHYSICS	FIS/01	06 CFU
II s	[302BB] PARTICLE PHYSICS	FIS/04	09 CFU
II s	[0046B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES	FIS/01	09 CFU
II s	[378BB] RECENT HIGHLIGHTS IN FUNDAMENTAL INTERACTIONS	FIS/04	03 CFU
A	[SNS-SMB] STANDARD MODEL AND BEYOND	FIS/02	06 CFU

Additional Notes

MEDICAL PHYSICS

Insegnamenti vincolati del PdS

minimo

51 CFU

Gruppo obbligatori (tutti i seguenti)

I s	[205BB] MEDICAL PHYSICS	FIS/07	09 CFU
A	[281BB] MEDICAL PHYSICS LABORATORY	FIS/07	15 CFU
II s	[0037B] MOLECULAR IMAGING	FIS/07	06 CFU

Gruppo fisica teorica (almeno uno dei seguenti)

I s	[228BB] GENERAL RELATIVITY	FIS/02	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo microfisica e struttura della materia (almeno uno dei seguenti)

I s	[305BB] FUNDAMENTAL INTERACTIONS	FIS/04	09 CFU
I s	[399BB] INTRODUCTION TO MOLECULAR BIOPHYSICS	FIS/03	06 CFU
I s	[206BB] NUCLEAR PHYSICS	FIS/04	09 CFU
I s	[387BB] PHYSICS OF BIOSYSTEMS	FIS/03	09 CFU

Gruppo astrofisica (almeno uno dei seguenti)

II s	[063BB] ASTROPARTICLE PHYSICS S	FIS/05	06 CFU
II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

24 CFU

(almeno 9CFU dai seguenti o dai vincolati non scelti)

I s	[360BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS	FIS/01	09 CFU
I s	[365BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS S	FIS/01	06 CFU
I s	[478EE] ELEMENTS OF PHYSIOLOGY, PHYSIOPATHOLOGY AND DIAGNOSTICS	BIO/09	06 CFU
I s	[305BB] FUNDAMENTAL INTERACTIONS	FIS/04	09 CFU
I s	[304BB] FUNDAMENTALS OF LIGHT MATTER INTERACTION	FIS/03	09 CFU
I s	[399BB] INTRODUCTION TO MOLECULAR BIOPHYSICS	FIS/03	06 CFU
I s	[206BB] NUCLEAR PHYSICS	FIS/04	09 CFU
I s	[387BB] PHYSICS OF BIOSYSTEMS	FIS/03	09 CFU
I s	[338BB] SIGNAL PROCESSING FOR PHYSICS	FIS/01	06 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU
II s	[217BB] ACCELERATOR PHYSICS	FIS/04	09 CFU
II s	[107BB] ACCELERATOR PHYSICS S	FIS/01	06 CFU
II s	[0008B] BIOPHYSICS OF EFLASH THERAPY	FIS/07	09 CFU
II s	[0039E] CELL BIOPHYSICS	BIO/10	03 CFU
II s	[0035B] DESIGN OF DIGITAL SYSTEMS FOR RADIATION DETECTION	FIS/07	06 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
II s	[198BB] DOSIMETRY	FIS/07	06 CFU
II s	[0004B] FLEXIBLE AND NANO-ELECTRONICS	FIS/03	09 CFU
II s	[0021B] MICROBIOROBOTICS	FIS/03	06 CFU
II s	[185BB] MONTECARLO METHODS IN EXPERIMENTAL PHYSICS	FIS/01	06 CFU
II s	[0020B] NEUROENGINEERING	FIS/03	06 CFU
II s	[124BB] NUCLEAR MAGNETIC RESONANCE	FIS/07	06 CFU
II s	[0040B] QUANTUM BIOLOGY	FIS/03	09 CFU
A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU

Additional Notes

As further guidance for your selection, some suggested study paths are listed below.

MEDICAL PHYSICS Path. This path is recommended for students interested in deepening their knowledge of physical methodologies applied to medicine, also with a view to a potential professional career as a medical physics specialist.

(from the "Microphysics group")

[206BB] Nuclear physics (FIS/04) 9 CFU

(from "Elective Courses")

[360BB] Computing methods for experimental physics and data analysis (FIS/01) 9 CFU

[198BB] Dosimetry (FIS/07) 6 CFU

[124BB] Nuclear magnetic resonance (FIS/07) 6 CFU.

FLASH RT Path. This path is recommended for students wishing to gain in-depth knowledge of the physical phenomena and radiobiological mechanisms underlying FLASH radiotherapy, providing both computational and experimental expertise relevant to research



in the field.

(from the “Microphysics group”)

[399BB] Introduction to molecular biophysics (FIS/03) 6 CFU

(from “Elective Courses”)

[0008B] Biophysics for eflash therapy (FIS/07) 9 CFU

[360BB] Computing methods for experimental physics and data analysis (FIS/01) 9 CFU

[185BB] Montecarlo methods in experimental physics (FIS/01) 6 CFU

BIOMEDICAL IMAGING Path. Recommended for students interested in developing a deeper understanding of the physical principles and technologies used to generate and analyze images of biological phenomena across multiple dimensional scales.

(from the “Microphysics group”)

[399BB] Introduction to molecular biophysics (FIS/03) 6 CFU

(from “Elective Courses”)

[360BB] Computing methods for experimental physics and data analysis (FIS/01) 9 CFU

[124BB] Nuclear magnetic resonance (FIS/07) 6 CFU

[387BB] Physics of biosystems (FIS/03) 9 CFU

INSTRUMENTATION FOR MEDICAL PHYSICS Path. Recommended for students interested in technologies for biomedical imaging and radiotherapy, with particular focus on the instrumental, computational, and physical aspects involved in developing and optimizing data acquisition, dosimetric, and imaging systems.

(from the “Microphysics group”)

[206BB] Nuclear Physics (FIS/04) 9 CFU

(from “Elective Courses”)

[107BB] Accelerator physics S (FIS/04) 6 CFU

[360BB] Computing methods for experimental physics and data analysis (FIS/01) 9 CFU

[0035B] Design of digital systems for radiation detection (FIS/07) 6 CFU



PHENOMENOLOGY OF FUNDAMENTAL INTERACTIONS

Insegnamenti vincolati del PdS

minimo

66 CFU

Gruppo obbligatori

(tutti i seguenti)

II s	[214BB] ADVANCED QUANTUM FIELD THEORY	FIS/02	09 CFU
II s	[192BB] ASTROPARTICLE PHYSICS	FIS/05	09 CFU
I s	[305BB] FUNDAMENTAL INTERACTIONS	FIS/04	09 CFU
I s	[228BB] GENERAL RELATIVITY	FIS/02	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU

Gruppo fisica teorica, nucleare e subnucleare

(almeno uno dei seguenti)

A	[SNS-EFT] EFFECTIVE FIELD THEORIES I AND II	FIS/02	06 CFU
I s	[206BB] NUCLEAR PHYSICS	FIS/04	09 CFU
II s	[197BB] QUANTUM CHROMODYNAMICS	FIS/02	09 CFU
A	[SNS-SMB] STANDARD MODEL AND BEYOND	FIS/02	06 CFU

Gruppo fisica sperimentale, nucleare e subnucleare (gruppo 2)

(almeno uno fra i seguenti)

II s	[308BB] DISCRETE SYMMETRIES	FIS/04	06 CFU
II s	[201BB] HADRON COLLIDER PHYSICS	FIS/04	09 CFU
I s	[427BB] PARTICLE DARK MATTER	FIS/01	06 CFU
II s	[302BB] PARTICLE PHYSICS	FIS/04	09 CFU

Gruppo fisica sperimentale

(almeno uno fra i seguenti)

A	[0010B] ASTROPHYSICS AND MULTIMESSENGER LABORATORY	FIS/01	12 CFU
I s	[360BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS	FIS/01	09 CFU
A	[414BB] LABORATORIO INTERAZIONI FONDAMENTALI S	FIS/01	09 CFU
II s	[0007B] QUANTUM TECHNOLOGIES FOR FUNDAMENTAL INTERACTION PHYSICS	FIS/01	09 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU

Insegnamenti a scelta consigliati

massimo

9 CFU

(include gli insegnamenti vincolati non scelti)

Additional Notes

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PHYSICS FOR CULTURAL HERITAGE

Insegnamenti vincolati del PdS

minimo

54 CFU

Gruppo obbligatori

(tutti i seguenti)

I s	[360BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS	FIS/01	09 CFU
I s	[304BB] FUNDAMENTALS OF LIGHT MATTER INTERACTION	FIS/03	09 CFU
I s	[418BB] PHYSICS FOR CULTURAL HERITAGE	FIS/07	09 CFU

Gruppo tematico

(almeno uno dei seguenti insegnamenti metodologici di ambito archeologico/storico/artistico)

I s	[402LL] ARCHEOLOGY OF PRODUCTION	L-ANT/10	06 CFU
–	[614LL] HISTORY OF ART RESTORATION	L-ART/04	06 CFU
I s	[1261L] HISTORY OF ARTISTIC TECHNIQUES	L-ART/04	06 CFU
I s	[289LL] METHODOLOGY OF HISTORICAL-ARTISTIC RESEARCH	L-ART/04	06 CFU
I s	[1276L] METHODS OF ARCHAEOLOGICAL RESEARCH	L-ANT/10	06 CFU
I s	[1407L] PALEOECOLOGIA E BIOARCHEOLOGIA	L-ANT/10	06 CFU

Gruppo fisica teorica

(almeno uno fra i seguenti)

I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo microfisica e struttura della materia

(almeno uno fra i seguenti)

I s	[206BB] NUCLEAR PHYSICS	FIS/04	09 CFU
I s	[0043B] PHOTONICS AND MATERIALS	FIS/03	06 CFU

Gruppo astrofisica

(almeno uno fra i seguenti)

II s	[192BB] ASTROPARTICLE PHYSICS	FIS/05	09 CFU
II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

21 CFU

(include i vincolati non scelti, ed eventuali altri insegnamenti di ambito archeologico/storico/artistico)

I s	[244CC] CHEMICAL PHYSICS OF MOLECULES	CHIM/02	09 CFU
I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[1237L] DIAGNOSTICS FOR THE STUDY OF WORKS OF ART	L-ART/04	12 CFU
I s	[309BB] DISORDERED SYSTEMS OUT OF EQUILIBRIUM	FIS/03	09 CFU
I s	[0024B] FLUID DYNAMICS	FIS/03	06 CFU
I s	[305BB] FUNDAMENTAL INTERACTIONS	FIS/04	09 CFU
I s	[387BB] PHYSICS OF BIOSYSTEMS	FIS/03	09 CFU
I s	[1095I] RADIATION PROTECTION	ING-IND/20	06 CFU
I s	[338BB] SIGNAL PROCESSING FOR PHYSICS	FIS/01	06 CFU
II s	[217BB] ACCELERATOR PHYSICS	FIS/04	09 CFU
II s	[221BB] ATOM OPTICS	FIS/03	09 CFU
II s	[1403L] COMPETENZE DIGITALI PER I BENI CULTURALI	L-ANT/10	06 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
II s	[198BB] DOSIMETRY	FIS/07	06 CFU
II s	[080BB] ELECTRONICS AND SENSORS	FIS/07	06 CFU
II s	[124BB] NUCLEAR MAGNETIC RESONANCE	FIS/07	06 CFU
II s	[203BB] PHYSICS OF PHOTONIC DEVICES	FIS/03	09 CFU
II s	[354BB] QUANTUM OPTICS AND PLASMA PHYSICS	FIS/03	09 CFU
A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU
A	[414BB] LABORATORIO INTERAZIONI FONDAMENTALI S	FIS/01	09 CFU
A	[281BB] MEDICAL PHYSICS LABORATORY	FIS/07	15 CFU
A	[412BB] PHYSICS OF MATTER AND NANOTECHNOLOGY LABORATORY S	FIS/01	09 CFU

Additional Notes

- Among the modules of the course [360BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS, the module “Medical Imaging” must be included.

PHYSICS OF BIOSYSTEMS

Insegnamenti vincolati del PdS

minimo

54 CFU

Gruppo obbligatori (tutti i seguenti)

I s	[304BB] FUNDAMENTALS OF LIGHT MATTER INTERACTION	FIS/03	09 CFU
I s	[387BB] PHYSICS OF BIOSYSTEMS	FIS/03	09 CFU

Gruppo fisica della materia (almeno uno dei seguenti)

I s	[309BB] DISORDERED SYSTEMS OUT OF EQUILIBRIUM	FIS/03	09 CFU
I s	[399BB] INTRODUCTION TO MOLECULAR BIOPHYSICS	FIS/03	06 CFU

Gruppo fisica sperimentale (almeno uno fra i seguenti)

A	[403BB] BIO-SYSTEMS LAB	FIS/01	15 CFU
A	[411BB] PHYSICS OF MATTER AND NANOTECHNOLOGY LABORATORY	FIS/01	15 CFU

Gruppo fisica teorica (almeno uno fra i seguenti)

I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo astrofisica (almeno uno dei seguenti)

II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

21 CFU

(include gli insegnamenti vincolati non scelti e quelli a seguire)

I s	[1054I] BIOFLUIDS AND MATERIALS INTERACTIONS	ING-IND/22	03 CFU
I s	[178EE] BIOINFORMATICS	INF/01	03 CFU
I s	[244CC] CHEMICAL PHYSICS OF MOLECULES	CHIM/02	09 CFU
I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[365BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS S	FIS/01	06 CFU
I s	[399BB] INTRODUCTION TO MOLECULAR BIOPHYSICS	FIS/03	06 CFU
I s	[1057I] MANUFACTURING OF POLYMERS AND NANOCOMPOSITES FOR BIOMEDICAL APPLICATION	ING-IND/22	03 CFU
I s	[205BB] MEDICAL PHYSICS	FIS/07	09 CFU
I s	[1053I] NANOMEDICINE AND REGENERATIVE MEDICINE	ING-IND/22	06 CFU
I s	[0043B] PHOTONICS AND MATERIALS	FIS/03	06 CFU
I s	[204BB] SOLID STATE PHYSICS	FIS/03	09 CFU
II s	[0005B] 3D AND 4D NANOMATERIALS AND DEVICES	FIS/03	09 CFU
II s	[728II] BIOMATERIALS	ING-IND/22	06 CFU
II s	[0008B] BIOPHYSICS OF EFLASH THERAPY	FIS/07	09 CFU
II s	[0039E] CELL BIOPHYSICS	BIO/10	03 CFU
II s	[0042B] GRAPHICS AND ANIMATION WITH PYTHON	FIS/03	03 CFU
II s	[0021B] MICROBIOROBOTICS	FIS/03	06 CFU
II s	[0037B] MOLECULAR IMAGING	FIS/07	06 CFU
II s	[0020B] NEUROENGINEERING	FIS/03	06 CFU
II s	[0040B] QUANTUM BIOLOGY	FIS/03	09 CFU
II s	[383BB] SPECTROSCOPY AND MICROSCOPY OF NANOMATERIALS	FIS/03	06 CFU
A	[374BB] COMPUTATIONAL PHYSICS LABORATORY S	FIS/01	06 CFU
A	[1056I] FUNDAMENTALS OF BIOPHYSICS AT THE NANOSCALE	ING-IND/22	06 CFU
A	[SNS-PLC] PHYSICS OF THE LIVING CELL	FIS/03	06 CFU

Additional Notes

Note that it is possible to replace [411BB] LABORATORY OF PHYSICS OF MATTER AND NANOTECHNOLOGIES (15 CFU) with the “short” version [412BB] worth 9 CFU, together with 6 CFU from [326BB] NUMERICAL METHODS FOR PHYSICS (modules “First-principles calculations” and “Classical molecular dynamics”).

In the context of some possible thematic tracks in Biophysics of Biosystems, the following courses are suggested:

BIOPHYSICS Path: a path that deepens the processes and techniques involved in cellular and molecular biophysics.

- [403BB] Bio-systems lab (15 CFU)
- [0039E] Cell biophysics (3 CFU)
- [309BB] Disordered systems out of equilibrium (9 CFU)
- [399BB] Introduction to molecular biophysics (6 CFU)

ACTIVE MATTER Path: a path that provides the physical foundations that characterize the complexity and mechanisms underlying “bio-inspired” materials.



- [230BB] Complex systems (9 CFU)
- [309BB] Disordered systems out of equilibrium (9 CFU)
- [0021B] Microbiorobotics (6 CFU)
- [411BB] Physics of matter and nanotechnology laboratory (15 CFU)

BIOPHYSICS FOR FLASH Path (experimental): a path that provides basic physical knowledge of experimental biophysical mechanisms and techniques for studying the effects induced by FLASH radiotherapy.

- [0008B] Biophysics for eflash therapy (9 CFU)
- [403BB] Bio-systems lab (15 CFU)
- [399BB] Introduction to molecular biophysics (6 CFU)
- [205BB] Medical physics (9 CFU)
- [0042B] Graphics and animation with python (3 CFU)

BIOPHYSICS FOR FLASH Path (computational): a path that provides basic physical knowledge of computational biophysical mechanisms and techniques for studying the effects induced by FLASH radiotherapy.

- [0008B] Biophysics for eflash therapy (9 CFU)
- [399BB] Introduction to molecular biophysics (6 CFU)
- [205BB] Medical physics (9 CFU)
- [412BB] Physics of matter and nanotechnology laboratory S (9 CFU)
- [374BB] Computational physics laboratory S (6 CFU)

**PHYSICS OF GEOFLUIDS DYNAMICS AND SOLID EARTH****Insegnamenti vincolati del PdS**

minimo

66 CFU

Gruppo obbligatori*(tutti i seguenti, eccetto 0024B se già dato alla LT)*

I s	[0048B] EARTH SENSING AND GEOPHYSICAL MONITORING INSTRUMENTATION	FIS/03	06 CFU
I s	[0024B] FLUID DYNAMICS	FIS/03	06 CFU
II s	[0022B] LABORATORY OF INSTRUMENTAL SEISMOLOGY	FIS/01	09 CFU
II s	[0023B] MECHANICS OF GEOPHYSICAL FLUIDS	FIS/06	09 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
I s	[346BB] ROCK PHYSICS	FIS/03	06 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo tematici*(almeno due dei seguenti)*

I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[454II] COMPUTATIONAL FLUIDODYNAMICS	ING-IND/06	06 CFU
II s	[288DD] EARTHQUAKE SEISMOLOGY	GEO/10	06 CFU
II s	[375BB] LARGE SCALE PHYSICAL OCEANOGRAPHY	FIS/03	09 CFU
I s	[338BB] SIGNAL PROCESSING FOR PHYSICS	FIS/01	06 CFU

Insegnamenti a scelta consigliati

massimo

9 CFU

(include gli insegnamenti vincolati non scelti e quelli a seguire)

I s	[226BB] ASTROPHYSICAL PROCESSES	FIS/05	09 CFU
I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[454II] COMPUTATIONAL FLUIDODYNAMICS	ING-IND/06	06 CFU
I s	[309BB] DISORDERED SYSTEMS OUT OF EQUILIBRIUM	FIS/03	09 CFU
I s	[1074I] INTRODUCTION TO MACHINE LEARNING IN GEOPHYSICS	GEO/11	03 CFU
I s	[234DD] INVERSE PROBLEMS IN GEOPHYSICS	GEO/11	06 CFU
I s	[338BB] SIGNAL PROCESSING FOR PHYSICS	FIS/01	06 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU
II s	[267DD] COMPUTATIONAL GEOPHYSICS	GEO/11	06 CFU
II s	[288DD] EARTHQUAKE SEISMOLOGY	GEO/10	06 CFU
II s	[375BB] LARGE SCALE PHYSICAL OCEANOGRAPHY	FIS/03	09 CFU
II s	[322BB] NONLINEAR DYNAMICS	FIS/03	09 CFU

Additional Notes

PHYSICS OF MATTER

Insegnamenti vincolati del PdS

minimo

57 CFU

Gruppo obbligatori

(tutti i seguenti)

I s	[304BB] FUNDAMENTALS OF LIGHT MATTER INTERACTION	FIS/03	09 CFU
A	[411BB] PHYSICS OF MATTER AND NANOTECHNOLOGY LABORATORY	FIS/01	15 CFU

Gruppo fisica della materia (gruppo 1)

(almeno uno dei seguenti)

I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
I s	[204BB] SOLID STATE PHYSICS	FIS/03	09 CFU

Gruppo fisica della materia (gruppo 2)

(almeno uno dei seguenti)

I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[309BB] DISORDERED SYSTEMS OUT OF EQUILIBRIUM	FIS/03	09 CFU

Gruppo fisica teorica

(almeno uno dei seguenti)

I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo astrofisica

(almeno uno dei seguenti)

II s	[063BB] ASTROPARTICLE PHYSICS S	FIS/05	06 CFU
II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

18 CFU

(include gli insegnamenti vincolati non scelti e quelli a seguire)

I s	[244CC] CHEMICAL PHYSICS OF MOLECULES	CHIM/02	09 CFU
I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[309BB] DISORDERED SYSTEMS OUT OF EQUILIBRIUM	FIS/03	09 CFU
I s	[0024B] FLUID DYNAMICS	FIS/03	06 CFU
I s	[0045B] GROUP THEORY FOR MATERIAL SCIENCE	FIS/03	03 CFU
I s	[399BB] INTRODUCTION TO MOLECULAR BIOPHYSICS	FIS/03	06 CFU
I s	[0043B] PHOTONICS AND MATERIALS	FIS/03	06 CFU
I s	[387BB] PHYSICS OF BIOSYSTEMS	FIS/03	09 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
I s	[376BB] QUANTUM COMPUTING AND TECHNOLOGIES	FIS/03	09 CFU
I s	[382BB] QUANTUM LIQUIDS	FIS/03	09 CFU
I s	[204BB] SOLID STATE PHYSICS	FIS/03	09 CFU
II s	[0005B] 3D AND 4D NANOMATERIALS AND DEVICES	FIS/03	09 CFU
II s	[221BB] ATOM OPTICS	FIS/03	09 CFU
II s	[0039E] CELL BIOPHYSICS	BIO/10	03 CFU
II s	[370BB] CONDENSED MATTER PHYSICS	FIS/03	09 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
II s	[426BB] ENTANGLEMENT: ADVANCED THEORETICAL CONCEPTS AND APPLICATIONS IN QUANTUM TECHNOLOGIES	FIS/03	03 CFU
II s	[0004B] FLEXIBLE AND NANO-ELECTRONICS	FIS/03	09 CFU
II s	[0042B] GRAPHICS AND ANIMATION WITH PYTHON	FIS/03	03 CFU
II s	[0034B] INTRODUCTION TO THE PHYSICS OF CONTROLLED NUCLEAR FUSION	FIS/03	06 CFU
II s	[322BB] NONLINEAR DYNAMICS	FIS/03	09 CFU
II s	[203BB] PHYSICS OF PHOTONIC DEVICES	FIS/03	09 CFU
II s	[354BB] QUANTUM OPTICS AND PLASMA PHYSICS	FIS/03	09 CFU
II s	[0007B] QUANTUM TECHNOLOGIES FOR FUNDAMENTAL INTERACTION PHYSICS	FIS/01	09 CFU
II s	[383BB] SPECTROSCOPY AND MICROSCOPY OF NANOMATERIALS	FIS/03	06 CFU
A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU

Additional Notes

- As an alternative to [411BB] LABORATORY OF PHYSICS OF MATTER AND NANOTECHNOLOGIES (15 CFU), it is possible to take the “short” version [412BB] worth 9 CFU, in combination with at least two modules (for 6 CFU) from [326BB] NUMERICAL METHODS FOR PHYSICS. The modules “First-principles calculations” and “Classical molecular dynamics” are strongly recommended.

PHYSICS OF THE UNIVERSE

Insegnamenti vincolati del PdS

minimo

60 CFU

Gruppo obbligatori

(tutti i seguenti)

II s	[192BB] ASTROPARTICLE PHYSICS	FIS/05	09 CFU
A	[0010B] ASTROPHYSICS AND MULTIMESSENGER LABORATORY	FIS/01	12 CFU
I s	[228BB] GENERAL RELATIVITY	FIS/02	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU

Gruppo fisica sperimentale

(almeno uno dei seguenti)

A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU
II s	[0046B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES	FIS/01	09 CFU
II s	[0007B] QUANTUM TECHNOLOGIES FOR FUNDAMENTAL INTERACTION PHYSICS	FIS/01	09 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU

Gruppo microfisica e struttura della materia

(almeno uno dei seguenti)

II s	[091BB] COMPACT STAR PHYSICS S	FIS/04	06 CFU
I s	[304BB] FUNDAMENTALS OF LIGHT MATTER INTERACTION	FIS/03	09 CFU

Gruppo astrofisica

(almeno uno dei seguenti)

I s	[226BB] ASTROPHYSICAL PROCESSES	FIS/05	09 CFU
II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
II s	[275BB] COSMOLOGY OF THE EARLY UNIVERSE S	FIS/05	06 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

15 CFU

(include gli insegnamenti vincolati non scelti e quelli a seguire)

I s	[0013B] ADVANCED TECHNOLOGIES FOR GROUND-BASED ASTROPHYSICS: FROM MICROWAVES TO VISIBLE LIGHT	FIS/05	06 CFU
I s	[306BB] EXPERIMENTAL METHODS FOR ASTROPARTICLE PHYSICS	FIS/01	09 CFU
I s	[305BB] FUNDAMENTAL INTERACTIONS	FIS/04	09 CFU
I s	[385BB] INTRODUCTION TO NEUTRINO PHYSICS	FIS/04	03 CFU
I s	[0011B] MULTIMESSENGER AND HIGH-ENERGY ASTROPHYSICS	FIS/05	06 CFU
I s	[427BB] PARTICLE DARK MATTER	FIS/01	06 CFU
I s	[0012B] PHYSICS OF STAR FORMATION	FIS/05	06 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
II s	[214BB] ADVANCED QUANTUM FIELD THEORY	FIS/02	09 CFU
II s	[091BB] COMPACT STAR PHYSICS S	FIS/04	06 CFU
II s	[274BB] COSMOLOGY OF THE EARLY UNIVERSE	FIS/05	09 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
II s	[369BB] EXTRAGALACTIC ASTROPHYSICS AND COSMOLOGY	FIS/05	09 CFU
II s	[140BB] GRAVITATION THEORIES S	FIS/02	06 CFU
II s	[251BB] GRAVITATION THEORY	FIS/02	09 CFU
II s	[0046B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES	FIS/01	09 CFU
II s	[0047B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES S	FIS/01	06 CFU
II s	[0016B] THEORY OF NUCLEAR INTERACTION S	FIS/02	06 CFU
A	[414BB] LABORATORIO INTERAZIONI FONDAMENTALI S	FIS/01	09 CFU

Additional Notes

Within some possible thematic tracks in Physics of the Universe, the following elective courses are suggested:

GRAVITATIONAL WAVES and COMPACT OBJECTS Track:

- [091BB] Compact star physics S (6 CFU)
- [0046B] Physics and detectors of gravitational wave physics (9 CFU or short version 6 CFU [0047B])
- [251BB] Gravitation theory (9 CFU or short version 6 CFU [140BB])

COSMOLOGY and DARK MATTER Track:

- [274BB] Cosmology of the early universe (9 CFU)
- [369BB] Extragalactic astrophysics and cosmology (9 CFU)
- [427BB] Particle dark matter (6 CFU)

PLASMA PHYSICS

Insegnamenti vincolati del PdS

minimo

60 CFU

Gruppo obbligatori

(tutti i seguenti, eccetto 0024B se già dato alla LT)

A	[374BB] COMPUTATIONAL PHYSICS LABORATORY S	FIS/01	06 CFU
I s	[0024B] FLUID DYNAMICS	FIS/03	06 CFU
I s	[304BB] FUNDAMENTALS OF LIGHT MATTER INTERACTION	FIS/03	09 CFU
A	[412BB] PHYSICS OF MATTER AND NANOTECHNOLOGY LABORATORY S	FIS/01	09 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo tematico

(almeno due dei seguenti)

I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[454II] COMPUTATIONAL FLUIDODYNAMICS	ING-IND/06	06 CFU
II s	[0034B] INTRODUCTION TO THE PHYSICS OF CONTROLLED NUCLEAR FUSION	FIS/03	06 CFU
II s	[0023B] MECHANICS OF GEOPHYSICAL FLUIDS	FIS/06	09 CFU

Insegnamenti a scelta consigliati

massimo

15 CFU

(include gli insegnamenti vincolati non scelti e quelli a seguire)

I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[454II] COMPUTATIONAL FLUIDODYNAMICS	ING-IND/06	06 CFU
I s	[365BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS S	FIS/01	06 CFU
I s	[309BB] DISORDERED SYSTEMS OUT OF EQUILIBRIUM	FIS/03	09 CFU
I s	[399BB] INTRODUCTION TO MOLECULAR BIOPHYSICS	FIS/03	06 CFU
I s	[654AA] MACHINE LEARNING	INF/01	09 CFU
I s	[387BB] PHYSICS OF BIOSYSTEMS	FIS/03	09 CFU
I s	[376BB] QUANTUM COMPUTING AND TECHNOLOGIES	FIS/03	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[204BB] SOLID STATE PHYSICS	FIS/03	09 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU
II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
II s	[221BB] ATOM OPTICS	FIS/03	09 CFU
II s	[279BB] COMPLEX SYSTEMS - NEURAL DYNAMICS	FIS/03	09 CFU
II s	[370BB] CONDENSED MATTER PHYSICS	FIS/03	09 CFU
II s	[0034B] INTRODUCTION TO THE PHYSICS OF CONTROLLED NUCLEAR FUSION	FIS/03	06 CFU
II s	[0022B] LABORATORY OF INSTRUMENTAL SEISMOLOGY	FIS/01	09 CFU
II s	[375BB] LARGE SCALE PHYSICAL OCEANOGRAPHY	FIS/03	09 CFU
II s	[0023B] MECHANICS OF GEOPHYSICAL FLUIDS	FIS/06	09 CFU
II s	[322BB] NONLINEAR DYNAMICS	FIS/03	09 CFU
II s	[354BB] QUANTUM OPTICS AND PLASMA PHYSICS	FIS/03	09 CFU
II s	[425BB] QUANTUM THERMODYNAMICS	FIS/03	06 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU
A	[SNS-SMLM] STATISTICAL AND MACHINE LEARNING MODELS FOR TIME SERIES ANALYSIS	FIS/03	06 CFU

Additional Notes

QUANTUM COMPUTING AND TECHNOLOGIES

Insegnamenti vincolati del PdS

minimo

42 CFU

Gruppo obbligatori

(tutti i seguenti)

I s	[376BB] QUANTUM COMPUTING AND TECHNOLOGIES	FIS/03	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo fisica materia

(almeno uno dei seguenti)

I s	[304BB] FUNDAMENTALS OF LIGHT MATTER INTERACTION	FIS/03	09 CFU
I s	[204BB] SOLID STATE PHYSICS	FIS/03	09 CFU

Gruppo fisica sperimentale

(almeno uno dei seguenti)

A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
A	[412BB] PHYSICS OF MATTER AND NANOTECHNOLOGY LABORATORY S	FIS/01	09 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU

Gruppo astrofisica

(almeno uno dei seguenti)

II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU

Insegnamenti a scelta consigliati

massimo

33 CFU

(include gli insegnamenti vincolati non scelti e quelli a seguire)

I s	[244CC] CHEMICAL PHYSICS OF MOLECULES	CHIM/02	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[382BB] QUANTUM LIQUIDS	FIS/03	09 CFU
II s	[214BB] ADVANCED QUANTUM FIELD THEORY	FIS/02	09 CFU
II s	[221BB] ATOM OPTICS	FIS/03	09 CFU
II s	[370BB] CONDENSED MATTER PHYSICS	FIS/03	09 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
II s	[426BB] ENTANGLEMENT: ADVANCED THEORETICAL CONCEPTS AND APPLICATIONS IN QUANTUM TECHNOLOGIES	FIS/03	03 CFU
II s	[827II] MATERIALS AND DEVICES FOR NANOSCALE ELECTRONICS	ING-INF/01	06 CFU
II s	[203BB] PHYSICS OF PHOTONIC DEVICES	FIS/03	09 CFU
II s	[0040B] QUANTUM BIOLOGY	FIS/03	09 CFU
II s	[0019B] QUANTUM MACHINE LEARNING	FIS/03	03 CFU
A	[SNS-MQT] METHODS IN QUANTUM TECHNOLOGIES: THEORY AND APPLICATIONS	FIS/03	08 CFU

Additional Notes



THEORETICAL PHYSICS

Insegnamenti vincolati del PdS

minimo

60 CFU

Gruppo obbligatori
(tutti i seguenti)

II s	[214BB] ADVANCED QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU

Approfondimento teorica
(almeno due fra i seguenti)

I s	[228BB] GENERAL RELATIVITY	FIS/02	09 CFU
I s	[206BB] NUCLEAR PHYSICS	FIS/04	09 CFU
II s	[197BB] QUANTUM CHROMODYNAMICS	FIS/02	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo fisica sperimentale
(almeno uno dei seguenti)

A	[0010B] ASTROPHYSICS AND MULTIMESSENGER LABORATORY	FIS/01	12 CFU
A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU
I s	[360BB] COMPUTING METHODS FOR EXPERIMENTAL PHYSICS AND DATA ANALYSIS	FIS/01	09 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
A	[414BB] LABORATORIO INTERAZIONI FONDAMENTALI S	FIS/01	09 CFU
II s	[0046B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES	FIS/01	09 CFU
A	[412BB] PHYSICS OF MATTER AND NANOTECHNOLOGY LABORATORY S	FIS/01	09 CFU
I s	[193BB] STATISTICAL DATA ANALYSIS	FIS/01	09 CFU

Gruppo microfisica e struttura della materia
(almeno uno dei seguenti, a meno che non sia stato scelto già [206BB] Nuclear Physics)

I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
II s	[370BB] CONDENSED MATTER PHYSICS	FIS/03	09 CFU
I s	[305BB] FUNDAMENTAL INTERACTIONS	FIS/04	09 CFU
I s	[304BB] FUNDAMENTALS OF LIGHT MATTER INTERACTION	FIS/03	09 CFU
I s	[206BB] NUCLEAR PHYSICS	FIS/04	09 CFU
I s	[376BB] QUANTUM COMPUTING AND TECHNOLOGIES	FIS/03	09 CFU
I s	[204BB] SOLID STATE PHYSICS	FIS/03	09 CFU

Gruppo astrofisica
(almeno uno dei seguenti)

II s	[192BB] ASTROPARTICLE PHYSICS	FIS/05	09 CFU
II s	[063BB] ASTROPARTICLE PHYSICS S	FIS/05	06 CFU
I s	[226BB] ASTROPHYSICAL PROCESSES	FIS/05	09 CFU
II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
II s	[274BB] COSMOLOGY OF THE EARLY UNIVERSE	FIS/05	09 CFU
II s	[275BB] COSMOLOGY OF THE EARLY UNIVERSE S	FIS/05	06 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
II s	[211BB] STELLAR PHYSICS	FIS/05	09 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

15 CFU

(include gli insegnamenti vincolati non scelti e quelli a seguire)

I s	[404BB] NONPERTURBATIVE APPROACHES TO QUANTUM FIELD THEORIES S	FIS/02	06 CFU
I s	[358BB] NONPERTURBATIVE APPROACHES TO QUANTUM FIELD THEORIES	FIS/02	09 CFU
I s	[427BB] PARTICLE DARK MATTER	FIS/01	06 CFU
II s	[091BB] COMPACT STAR PHYSICS S	FIS/04	06 CFU
II s	[274BB] COSMOLOGY OF THE EARLY UNIVERSE	FIS/05	09 CFU
II s	[275BB] COSMOLOGY OF THE EARLY UNIVERSE S	FIS/05	06 CFU
II s	[251BB] GRAVITATION THEORY	FIS/02	09 CFU
II s	[0046B] PHYSICS AND DETECTORS OF GRAVITATIONAL WAVES	FIS/01	09 CFU
II s	[425BB] QUANTUM THERMODYNAMICS	FIS/03	06 CFU
II s	[0016B] THEORY OF NUCLEAR INTERACTION S	FIS/02	06 CFU
A	[326BB] COMPUTATIONAL PHYSICS LABORATORY	FIS/01	09 CFU
A	[374BB] COMPUTATIONAL PHYSICS LABORATORY S	FIS/01	06 CFU
A	[SNS-EFT] EFFECTIVE FIELD THEORIES I AND II	FIS/02	06 CFU
A	[SNS-SMB] STANDARD MODEL AND BEYOND	FIS/02	06 CFU

Additional Notes

THEORY OF QUANTUM MATERIALS

Insegnamenti vincolati del PdS

minimo

48 CFU

Gruppo obbligatori

(tutti i seguenti)

A	[374BB] COMPUTATIONAL PHYSICS LABORATORY S	FIS/01	06 CFU
I s	[213BB] QUANTUM FIELD THEORY	FIS/02	09 CFU
I s	[204BB] SOLID STATE PHYSICS	FIS/03	09 CFU
I s	[207BB] STATISTICAL PHYSICS	FIS/02	09 CFU

Gruppo fisica materia

(almeno uno dei seguenti)

II s	[370BB] CONDENSED MATTER PHYSICS	FIS/03	09 CFU
I s	[382BB] QUANTUM LIQUIDS	FIS/03	09 CFU

Gruppo astrofisica

(almeno uno dei seguenti)

II s	[368BB] ASTROPHYSICS	FIS/05	06 CFU
I s	[353BB] PLASMA PHYSICS	FIS/03-05	09 CFU
II s	[098BB] STELLAR PHYSICS S	FIS/05	06 CFU

Insegnamenti a scelta consigliati

massimo

27 CFU

(include gli insegnamenti vincolati non scelti e quelli a seguire)

I s	[230BB] COMPLEX SYSTEMS	FIS/03	09 CFU
I s	[0024B] FLUID DYNAMICS	FIS/03	06 CFU
I s	[376BB] QUANTUM COMPUTING AND TECHNOLOGIES	FIS/03	09 CFU
I s	[382BB] QUANTUM LIQUIDS	FIS/03	09 CFU
II s	[214BB] ADVANCED QUANTUM FIELD THEORY	FIS/02	09 CFU
II s	[370BB] CONDENSED MATTER PHYSICS	FIS/03	09 CFU
II s	[0009B] DETECTION TECHNIQUES: FROM LAB TO SPACE	FIS/01	09 CFU
II s	[426BB] ENTANGLEMENT: ADVANCED THEORETICAL CONCEPTS AND APPLICATIONS IN QUANTUM TECHNOLOGIES	FIS/03	03 CFU
II s	[0004B] FLEXIBLE AND NANO-ELECTRONICS	FIS/03	09 CFU
II s	[0007B] QUANTUM TECHNOLOGIES FOR FUNDAMENTAL INTERACTION PHYSICS	FIS/01	09 CFU
II s	[425BB] QUANTUM THERMODYNAMICS	FIS/03	06 CFU
A	[SNS-MQT] METHODS IN QUANTUM TECHNOLOGIES: THEORY AND APPLICATIONS	FIS/03	08 CFU

Additional Notes

- In the course [374BB] NUMERICAL METHODS FOR PHYSICS S, the modules “First-principles calculations” and “Classical molecular dynamics” must be completed. It is also possible to take the 9 CFU version of Numerical Methods for Physics by adding an additional module to the two required ones.

FREE STUDY PLAN

According to the regulations, any Individual Study Plan (PdSI) must satisfy certain general requirements, including in particular:

- at least 6 CFU must be earned in courses from the FIS/01 sector;
- at least 6 CFU must be earned in courses from the FIS/02 sector;
- at least 6 CFU must be earned in courses from either the FIS/03 or FIS/04 sector;
- at least 6 CFU must be earned in courses from the FIS/05 sector.

For a complete list of the requirements that must be met—for example, regarding the total number of CFU dedicated to related and supplementary subjects—please refer to the official regulations of the Master's Degree Program. The total number of credits accumulated must reach 75 CFU, which combined with the 45 CFU of the final thesis leads to the required total of 120 CFU.

The simplest way to compose a free PdSI is to **start from one of the suggested Study Plans**, replacing some of the courses with others, in order to create a PdS that meets administrative requirements and forms a complete and coherent academic path. When submitting a free PdSI, it is required to **justify the choice with a comment in CAPS**. Note that comments can only be added after the PdSI has been submitted. The approval of the PdSI will be based on the adequacy of the proposed study path, which must consist of a set of courses that not only meet the general rules but also form a complete and coherent curriculum. In particular, make sure to respect prerequisites and avoid courses with overlapping syllabi. Be aware that the approval process for a free Study Plan is inherently slower and the outcome is not guaranteed.