

MASTER COURSE “PHYSICS” – UNIVERSITY OF FERRARA SUGGESTED STUDY TRACKS

The Master Degree in Physics includes:

- 6 required courses;
- 6 optional courses;
- the preparation of the degree thesis.

The required courses, listed in the table here below, include both in-depth subjects in the field of theoretical physics and mathematical methods of physics, and an overview of topics related to the different sectors of experimental physics. Interdisciplinarity is in fact one of the distinguishing traits that are of paramount importance for the background knowledge of a modern physicist.

Required Courses	SSD	Att.	CFU	Sem./Anno
Mathematical Methods of Physics	FIS/02	B2	6	I/1
Quantum Mechanics	FIS/02	B2	6	I/1
Statistical Physics	FIS/04	B3	6	II/1
Elements of Subnuclear Physics	FIS/02	B2	6	II/1
Solid State Physics	FIS/03	B3	6	I/1
Astrophysical Processes (New)	FIS/01	B1	6	I/1

The optional courses allow to tailor the Master Degree in Physics according to personal cultural interests and to the possible post-graduate professional opportunities. In the present document some reference tracks are presented, that may help in the preparation of the individual study plan.

The rules that must be followed when preparing the individual study plan are presented in the table at the end of this document. Based on these formal rules, different reference tracks can be identified and are presented below. For each reference track, the students should choose among the listed Courses, paying attention to the suggested ones, selecting two Courses highlighted in **grey** and two in **yellow** in each track. The choice of the two remaining optional courses is free.

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FUNDAMENTAL PHYSICS
• Physics of Fundamental Interactions
• Condensed Matter
• Astrophysics and Cosmology
• Theoretical Physics
APPLIED PHYSICS
• Energy and Environment
• Medical Physics
DIDACTICS OF PHYSICS AND SCIENTIFIC DISSEMINATION

FUNDAMENTAL PHYSICS

- Physics of Fundamental Interactions**

This track offers to the students advanced knowledge of the experimental technology and data analysis applied in the sectors of particle and hadron physics. The students will have the chance to directly benefit of the many collaborations that the research groups of the University and of the Istituto Nazionale di Fisica Nucleare (INFN) have established with laboratories of excellence in the world.

Course	Sugg.	SSD	Att.	Table	CFU	Sem./Anno
Advanced electromagnetism		FIS/01	B1	I B	6	II/1
Introduction to particle accelerators and detectors	S	FIS/01	B1	I B	6	II/1
Object-oriented programming for experimental data analysis		FIS/01	B1	I B	6	I/1
Physics of electronic devices		FIS/01	B1	I B	6	I/1
Statistics and modelling of experimental data		FIS/01	B1	I B	6	I/1
Experimental particle physics	S	FIS/04	C	II C	6	II/2
High energy physics laboratory	S	FIS/04	C	II C	6	I/1
Elements of Quantum Field Theory		FIS/02	C	II A	6	II/1

S: Strongly suggested for this track

- Condensed Matter**

This track aims to give to the student a solid understanding of material properties at microscopic and macroscopic levels, encompassing two sub-tracks: Magnetism of Nanostructures and Semiconductor Physics. The topics range from those relating to fundamental properties of these structures, treated within the framework of Solid State Physics, to the experimental investigation and applications.

Course	Sugg.	SSD	Att.	Table	CFU	Sem./Anno
Advanced electromagnetism		FIS/01	B1	I B	6	II/1
Electron microscopy: theory and applications	M/S	FIS/01	B1	I B	6	I/1
Introduction to particle accelerators and detectors		FIS/01	B1	I B	6	II/1
Object-oriented programming for experimental data analysis		FIS/01	B1	I B	6	I/1
Physics of electronic devices		FIS/01	B1	I B	6	I/1
Semiconductor physics laboratory	M/S	FIS/01	B1	I B	6	II/1
Solar energy systems	S	FIS/01	B1	I B	6	II/1
Magnetic properties of matter and laboratory	M	FIS/03	C	II B	6	I/2
Sensors: physics and technology	S	FIS/03	C	II B	6	II/1
Surface physics and nanostructures	M/S	FIS/03	C	II B	6	I/1

M: Strongly suggested for the sub-track Magnetism of Nanostructures

S: Strongly suggested for the sub-track Semiconductor Physics

- Astrophysics and Cosmology**

This track aims at providing students with a comprehensive and up-to-date training on theoretical, observational and instrumentation areas in modern astrophysics and cosmology. Students will be involved in forefront research groups, particularly active in the fields of observational and theoretical cosmology, high-energy astrophysics, and multi-messenger astronomy, using ground/space based facilities and high-performance computing, as part of international collaborations.

Course	Sugg.	SSD	Att.	Table	CFU	Sem./Anno
Measures and observations of celestial X and gamma rays		FIS/01	B1	I B	6	II/1
Object-oriented programming for experimental data analysis		FIS/01	B1	I B	6	I/1
Relativity		FIS/01	B1	I B	6	II/1
Space physics		FIS/01	B1	I B	6	II/1
Astroparticle cosmology	S	FIS/05	C	II D	6	I/2
Multimessenger astrophysics	S	FIS/05	C	II D	6	II/1
Observational cosmology	S	FIS/05	C	II D	6	II/2

S: Strongly suggested for this track

- Theoretical Physics**

Theoretical physics draws inspiration from experimental data, that might appear as limited, fragmentary or even contradictory, and from these draws inspiration to build mathematical models that can explain and predict carefully the behavior of nature, highlighting symmetries and regularities at all scales. Theoretical research developed at the Department, with a dense plot of collaborations in Italy and abroad, covers almost all areas of physics, from the dynamics of the universe on a large scale up to that of the quarks that make up the elementary particles.

Course	Sugg.	SSD	Att.	Table	CFU	Sem./Anno
Advanced electromagnetism		FIS/01	B1	I B	6	II/1
Object-oriented programming for experimental data analysis		FIS/01	B1	I B	6	I/1
Physics of complex systems and laboratory		FIS/01	B1	I B	6	II/1
Relativity	S	FIS/01	B1	I B	6	II/1
Advanced Quantum Mechanics		FIS/02	C	II A	6	I/1 e 2
Applications of quantum field theory		FIS/02	C	II A	6	I/2
Elements of quantum field theory	S	FIS/02	C	II A	6	II/1
Artificial Intelligence (new)		FIS/02	C	II A	6	II/1
Nuclear physics		FIS/04	C	II C	6	I/2
Astroparticle cosmology		FIS/05	C	II D	6	I/2

S: Strongly suggested for this track

APPLIED PHYSICS

- **Energy and Environment**

This track is centered on the links between physics and some pivotal issues of our society, such as energy and the environment. A sound education in applied physics, including photovoltaics, renewable energy, nuclear technologies, semiconductor physics and devices, offers opportunities for the jobs of the future.

Course	Sugg.	SSD	Att.	Table	CFU	Sem./Anno
Electron microscopy: theory and applications		FIS/01	B1	I B	6	I/1
Environmental radioactivity	S	FIS/01	B1	I B	6	I/1
Energy and society	S	FIS/01	B1	I B	6	I/1
Solar energy systems	S	FIS/01	B1	I B	6	II/1
Semiconductor physics laboratory		FIS/01	B1	I B	6	II/1
Object-oriented programming for experimental data analysis		FIS/01	B1	I B	6	II/1
Nuclear and subnuclear geophysics	S	FIS/04	C	II C	6	II/1
Radiation physics for medical applications		FIS/07	C	II E	6	II/1
Insegnamenti suggeriti da altri Corsi di Studio						
Ecologia		BIO/07	LT/Sc.Biologiche		9	II
Economia ecologica		SECS-P/01	LM/Biotec.Amb.Sal.		6	I
Economics of innovation		SECS-P/06	LM/ Econom. Manag. Pol. Global Challenges		8	I
Energy and resource economics		SECS-P/03	LM/ Econom. Manag. Pol. Global Challenges		7	I
Impatto ambientale		BIO/07	LM/Biotec.Amb.Sal.		6	I
Prospezioni geofisiche		GEO/11	LM/ Sc. Geol. Geor. Territorio		6	II

S: Strongly suggested for this track

- **Medical Physics**

The courses of the Medical Physics track aim to provide the student with the knowledge of the physical principles of instrumentation used in diagnostic imaging and radiotherapy. In particular, the programs of the characterizing courses have been defined to deepen the study of medical equipment used both in emerging technologies and in clinical practice, in order to develop useful skills for a professional career in the world of scientific or industrial research, or as a medical physicist in the hospital after entering the specialization school.

Course	Sugg.	SSD	Att.	Table	CFU	Sem./Anno
Environmental radioactivity	S	FIS/01	B1	I B	6	I/1
Introduction to particle accelerators and detectors		FIS/01	B1	I B	6	II/1
Laboratory of archaeometry		FIS/01	B1	I B	6	II/1
Physics, energy and society		FIS/01	B1	I B	6	I/1
Medical physics	S	FIS/07	C	II E	6	II/1
Medical physics laboratory	S	FIS/07	C	II E	6	II/2
Radiation physics for medical applications (new title)	S	FIS/07	C	II E	6	II/1

S: Strongly suggested for this track

DIDACTICS OF PHYSICS AND SCIENTIFIC DISSEMINATION

This track concerns the students who are interested in teaching and in science dissemination activities, of always growing importance. Besides a deepening of the basic knowledge in physics and physics laboratory, the track suggests courses from other Departments that might complement the preparation of the student and pave the way to the access of the different teaching classes of the secondary schools.

Course	Sugg.	SSD	Att.	Table	CFU	Sem./Anno
Modern physics laboratory	S	FIS/01	B1	I B	6	
Advanced electromagnetism		FIS/01	B1	I B	6	II/1
Laboratory of archaeometry		FIS/01	B1	I B	6	II/1
Energy and society		FIS/01	B1	I B	6	I/1
Relativity		FIS/01	B1	I B	6	II/1
Statistics and modelling of experimental data		FIS/01	B1	I B	6	I/1
Experimental particle physics		FIS/04	C	II C	6	II/2
Medical physics		FIS/07	C	II E	6	II/1
Multimessenger astrophysics		FIS/05	C	II D	6	II/1
Nuclear physics		FIS/04	C	II C	6	I/2
Surface physics and nanostructures		FIS/03	C	II B	6	I/1
Insegnamenti della Laurea Triennale in Fisica						
Didattica della fisica e laboratorio	S	FIS/08	LT/Fisica		6	II/2
Epistemologia e storia della fisica	S	FIS/08	LT/Fisica		6	II/3
Insegnamenti suggeriti da altri Corsi di Studio						
Comunicazione della scienza	S	M-STO/05	LT/Sc.Tec.Com		6	I/2
Storia della scienza	S	M-STO/05	LT/Sc.Fil.Educ.		6	I/3
Didattica della matematica		MAT/04	LT/Matematica		9	I/1
Pedagogia generale		M-PED/01	LT/Sc.Fil.Educ.		12	II/1
Psicologia della comunicazione		M-PSI/01	LT/ Sc. Tecn. Comunicazione		6	I

S: Strongly suggested for this track

FORMAL RULES FOR THE COMPILATION OF THE STUDY PLAN

1st YEAR	
<p>To complete the first year of the course, a total of 60 credits must be obtained; 36 are obtained by giving the mandatory exams of the table above while the remaining 24 can be achieved in the following way:</p> <p style="text-align: center;">12 credits choosing among the characterizing courses of the SSD FIS/01 present Table I</p> <p>The remaining 12 credits can be obtained by following only one of the two options:</p>	
<p>Option 1</p> <ul style="list-style-type: none"> • 6 CFU choosing among the courses of SSD FIS/02-03-04-05-07 in Tables IIA-IIE • 6 CFU choosing a course of free choice (type D activity) 	<p>Option 2</p> <ul style="list-style-type: none"> • 12 CFU choosing among the courses of SSD FIS/02-03-04-05-07 in only one of Tables IIA-IIE
2nd YEAR	
<p>To complete the second year of the course, a total of 60 credits must be obtained</p> <ul style="list-style-type: none"> • 48 credits result from the thesis activity (45 credits) and type F activities (3 credits) • 12 credits can be achieved by following only one of these two options, in accordance to the choice of the 1st year 	
<p>Option 1</p> <ul style="list-style-type: none"> • 6 CFU choosing among the courses of SSD FIS/02-03-04-05-07 in Tables IIA-IIE (same of the first year) • 6 CFU choosing a course of free choice (type D activity) 	<p>Option 2</p> <ul style="list-style-type: none"> • 12 CFU choosing courses of free choice (type D activity)