

Curriculum in THEORETICAL PHYSICS

For students interested in

- 1) Physics of fundamental interactions (theory)
- 2) General relativity and theoretical astrophysics
- 3) Statistical mechanics and the physics of complex systems
- 4) Mathematical physics

People interested in condensed matter theory should consider the curriculum in condensed matter, while the biosystem curriculum is more appropriate for those that would like to study (theoretically) problems at the boundary of physics, biology and chemistry

**Corso di laurea in Fisica (LM-17) -
Curriculum Teorico Generale**

N.	Insegnamenti	CFU	anno	sem.	SSD	eng	ambito
1	Introduction to Quantum Field Theory	6	1	1	FIS/02	Y	caratt.
2	Condensed Matter Physics	6	1	1	FIS/03	Y	caratt.
3	Physics Laboratory I (insegnamento propedeutico a Physics Laboratory II)	6	1	1	FIS/01	Y	caratt.
4	Physics Laboratory II	9	1	2	FIS/01	Y	caratt.
5	Gruppo C	6	1	2	MAT/07	Y	aff.-int.
6	English language	4	1	2		Y	AAF
7	gruppo A	6	1/2	1/2			caratt.
8	gruppo A	6	1/2	1/2			caratt.
9	gruppo B	6	1/2	1/2			aff.-int.
10	Corso a scelta	6	1/2	1/2			
11	gruppo A	6	1/2	1/2			caratt.
12	gruppo B	6	1/2	1/2			aff.-int.
13	Corso a scelta	6	2	1			
14	Internship	3	2	1		Y	AAF
15	Thesis Project	38	2	2		Y	AAF

CFU=credits anno=year sem.=semester
 SSD: FIS=physics MAT=math INF=informatics
 eng: in English (Y) or in Italian (N)

5 MANDATORY COURSES

Gruppo C (aff.-int.)

1	Mathematical Physics	6	1	2	MAT/07	Y	
2	Group Theory in Mathematical Physics	6	1	2	MAT/07	Y	

3 COURSES FROM GROUP A 2 COURSES FROM GROUP B

Gruppo B (aff.-int.)

1	Computing Methods for Physics	6	1	1	INF/01	Y	
2	Statistical Mechanics and Critical Phenomena	6	1	1	FIS/02	Y	
3	Relatività generale	6	1	1	FIS/02	N	
4	Nonlinear and Quantum Optics	6	1	1	FIS/03	Y	
5	Electroweak Interactions	6	1	2	FIS/02	Y	
6	Theoretical Biophysics	6	1	2	FIS/02	Y	
7	Quantum electrodynamics	6	1	2	FIS/02	Y	
8	Meccanica Statistica del Non Equilibrio	6	1	2	FIS/02	N	
9	Onde gravitazionali, stelle e buchi neri	6	1	2	FIS/02	N	
10	Neural Networks	6	1	2	FIS/02	Y	
11	Symmetry and Fundamental interactions	6	1	2	FIS/02	Y	
12	Condensed Matter Physics II	6	1	2	FIS/03	Y	
13	Superconductivity and Superfluidity	6	1	2	FIS/03	Y	
14	Advanced Machine Learning for Physics	6	1	2	INF/01	Y	
15	Many-Body Physics	6	2	1	FIS/03	Y	
16	Physics of Complex Systems	6	2	1	FIS/03	Y	
17	Quantum information and Computation	6	2	1	FIS/01	Y	
18	Weak interactions in the standard model and beyond	6	2	1	FIS/02	Y	
19	Introduzione alla teoria dei processi stocastici ed applicazioni alla fisica	6	2	1	FIS/02	N	
20	Statistical Mechanics of Disordered Systems	6	2	1	FIS/02	Y	
21	Introduzione alla gravita' quantistica	6	2	1	FIS/02	Y	

Gruppo A (caratt.)

1	Statistical Mechanics and Critical Phenomena	6	1	1	FIS/02	Y	
2	Relatività generale (mutuato dal CdS di Astronomia e Astrofisica)	6	1	1	FIS/02	N	
3	Electroweak Interactions	6	1	2	FIS/02	Y	
4	Quantum electrodynamics	6	1	2	FIS/02	Y	
5	Meccanica Statistica del Non Equilibrio	6	1	2	FIS/02	N	
6	Nonlinear Waves and Solitons	6	1	2	FIS/02	Y	
7	Statistical Mechanics of Disordered Systems	6	2	1	FIS/02	Y	
8	Quantum Field Theory	6	2	1	FIS/02	Y	
9	Statistical Physics and Machine Learning	6	2	1	FIS/02	Y	

2 ELECTIVE COURSES (CORSO A SCELTA LIBERA)

Among the 7 courses, the student must choose 1 course which is NON-FIS

MANDATORY COURSES:

Physics Laboratory

A first semester course (theory) and a second semester course (lab activity): 2 different exams to be taken in the right order!

There are different labs that depend on the chosen curriculum

A) Particle and Astroparticle: Prof. Cavoto

B) Condensed Matter: Prof. Mariani

C) Biosystems: Prof. Ortolani

Students interested in HEP or Astrophysics should take Lab A

All other students can choose the Lab coherently with their studies and interests

MANDATORY COURSES: Mathematical Physics (Group C)

In the second semester you have to take **at least one course** in Group C (Mathematical Physics)

- Mathematical Physics: Prof. Caglioti
- Group Theory in Mathematical Theory: Prof. Panati

Students in HEP and Astrophysics should take GTMP, while students more interested in Statistical/Mathematical Physics are suggested to take MP

A well accepted Piano Formativo can contain **both courses**

INF-type course: Computing Methods in Physics

4 different courses with the same name:

- Prof. Pannarale, suggested to HEP students
- Prof. Crisanti, the most theoretical one (no lab classes)
- Prof. Bachelet and Prof. De Michele, more oriented to computational physics and condensed matter

Two “free choice” courses (corsi a scelta libera)

Can be chosen in Groups A, B, C and from other curricula as well from other Lauree Magistrali in Sapienza (e.g. Matematica)

The first year, it is possible to schedule a course which is given at the second year (i.e. to anticipate a second year course)

However, it is not possible to schedule in the second year a first year course (i.e. to postpone a first year course) because it may no longer be active (professor retiring or moving to another university etc.)

How many courses should be scheduled every year / semester?

The curriculum must be balanced: ideally the 12 courses should be divided 4 courses per semester

FIRST year: 5 mandatory courses + English = 37 CFU
3-5 more courses = 18-30 CFU

SECOND year: 2-4 courses = 12-24 CFU
thesis + internship = 41 CFU

strongly unbalanced curricula will not be approved

Some constraints

- 1) “Simmetrie e interazioni fondamentali” should be taken before “Weak interactions in the standard model and beyond”
- 2) “Statistical mechanics and critical phenomena” should be taken before “Statistical mechanics of disordered systems”
- 3) “Relatività generale” should be taken before “Onde gravitazionali, stelle e buchi neri”

Choose the thesis during the first semester of the second year

At that time the student will have meet all the teachers of the chosen courses

Courses in the second year present the most advanced arguments and help in choosing the most appropriate thesis subject

The thesis subject should be consistent with the chosen curriculum and with the chosen elective courses

INTERNSHIP(3 CFU): how it works in practice

1) After two months of working on the thesis, the thesis advisor should give the student a signed form, which certifies the work that has been done.

2) The student should register in INFOSTUD (same procedure as that for an exam) **in the due time.**

3) The day of the exam the student should go to the professor in charge of internships:

Particle and Astroparticle: Prof. Bagnaia

Condensed Matter: Prof. Mariani

Biosystems: Prof.ssa Giardina

General Theory: Prof. Bonciani

To be registered: the student must show the **form signed by the advisor and the standard form to register the exams** to the professor in charge.

Finally, the student will bring the form signed by the advisor to the secretary Marco Dante

Examples of “standard” Piani Formativi

- High energy physics
- Theoretical astrophysics
- Statistical physics, complex systems
- Mathematical physics

Theoretical HEP

1 year, 1 semester

- Introduction to Quantum Field Theory
- Condensed Matter Physics
- Physics Laboratory 1
- Computing Methods for Physics

1 year, 2 semester

- Physics Laboratory 2
- Group Theory in Mathematical Physics
- Quantum Electrodynamics
- Electroweak Interactions
- Symmetry and Fundamental Interactions

2 year, 1 semester

- Weak Interactions in the Standard Model and Beyond
- Quantum Field Theory

+ 1 free choice course

Theoretical Astrophysics

1 year, 1 semester

- Introduction to Quantum Field Theory
- Condensed Matter Physics
- Physics Laboratory 1
- Computing Methods for Physics
- Relatività generale

1 year, 2 semester

- Physics Laboratory 2
- Group Theory in Mathematical Physics
- Onde gravitazionali, stelle e buchi neri
- Quantum electrodynamics
- Physical Cosmology

2 year, 1 semester

- Introduzione alla gravita' quantistica
- Quantum field theory

Statistical Physics, Complex Systems

1 year, 1 semester

- Introduction to Quantum Field Theory
- Condensed Matter Physics
- Physics Laboratory 1
- Computing Methods for Physics
- Statistical Mechanics and Critical Phenomena

1 year, 2 semester

- Physics Laboratory 2
- Mathematical Physics
- Meccanica Statistica del Non Equilibrio
- Theoretical Biophysics / Neural Networks
- Advanced Machine Learning for Physics

2 year, 1 semester

- Statistical Mechanics of Disordered Systems
- Statistical Physics and Machine Learning
- Introduzione alla teoria dei processi stocastici ed applicazioni alla fisica
- Physics of Complex Systems
- Quantum Field Theory

a large number of courses...
you have to choose a subset

Mathematical Physics

1 year, 1 semester

- Introduction to Quantum Field Theory
- Condensed Matter Physics
- Physics Laboratory 1
- Statistical Mechanics and Critical Phenomena

1 year, 2 semester

- Physics Laboratory 2
- Mathematical Physics
- Group Theory in Mathematical Physics
- Nonlinear Waves and Solitons

many courses in the Laurea Magistrale in Matematica

- Istituzioni di Fisica Matematica, Prof. Benedetto
- Sistemi dinamici, Prof. Buttà
- Metodi matematici in meccanica statistica, Prof. Basile
- Metodi matematici in meccanica quantistica, Prof. Teta
- Meccanica dei fluidi e teorie cinetiche, Prof. Cavallaro

FOR QUESTIONS ON THE CURRICULUM
IN THEORETICAL PHYSICS:

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