

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

Theoretical physics of the fundamental interactions

One analyzes the structure of matter at the subnuclear level. The aim is that of giving predictions that can be compared with experiments at accelerators like CERN, in neutrino experiments... A new subfield is “Astroparticle physics”

Theoretical Astrophysics

Here one studies the structure and evolution of stars and black holes, gravitational waves (theory) in close connection with the experimental groups, cosmology ...

Complex systems and statistical mechanics

Addressed to students interested in the study of

- disordered systems, spin glasses, structural glasses, the statistical behavior of systems with intrinsic disorder
- statistical mechanics (both at the classical and quantum level) of non-equilibrium systems
- interdisciplinary activity on dynamic large-scale phenomena that occur in fields “beyond” physics (from biology to economics and social sciences) but that can be understood using statistical mechanics methods

Corso di laurea in Fisica (LM-17) - Curriculum Teorico Generale							
N.	Insegnamenti	CFU	anno	sem.	SSD	eng	ambito
1	Relativistic Quantum Mechanics	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	Mathematical Physics	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

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

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	Electroweak interactions	6	1	1	FIS/02	Y	
5	Nonlinear and Quantum Optics	6	1	1	FIS/03	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	Simmetrie ed interazioni fondamentali	6	1	2	FIS/02	N	
12	Condensed Matter Physics II	6	1	2	FIS/03	Y	
13	Superconductivity and Superfluidity	6	1	2	FIS/03	Y	
14	Many-Body Physics	6	2	1	FIS/03	Y	
15	Physics of Complex Systems	6	2	1	FIS/03	Y	
16	Introduction to Particle Physics	6	2	1	FIS/01	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	

CFU = number of credits
 Anno = year (first or second year)
 Sem. = semester in which the course is taught
 Eng = in English (Y) or in Italian (N)

SSD:
 FIS: Physics course
 CHIM: Chemistry course
 BIO: Biology course
 INF: Computer science course
 MAT: Mathematics course

FIVE MANDATORY COURSES

3 COURSES FROM GROUP A
 2 COURSES FROM GROUP B

2 ELECTIVE COURSES
 (CORSO A SCELTA LIBERA)

Among the 7 courses, the student must choose 1 course which is NON-FIS, i.e. labelled INF, MAT,CHIM, BIO

MANDATORY COURSES: PHYSICS LABORATORY

THERE IS A FIRST SEMESTER COURSE (THEORY) AND A SECOND SEMESTER COURSE (LAB ACTIVITY): TWO DIFFERENT EXAMS

THE EXAM OF PHYSICS LAB I SHOULD BE PASSED BEFORE THAT OF PHYSICS LAB II

There are different labs that depend on the chosen curriculum

Different labs

- A) Particle and Astroparticle: Prof. CAVOTO
- B) Condensed Matter: Prof. MARIANI
- C) Biosystems: Prof. ORTOLANI

Students interested in high-energy physics or general relativity should take Lab A

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

MANDATORY COURSES: RELATIVISTIC QUANTUM MECHANICS

TWO DIFFERENT COURSES:

a) GENERAL COURSE (4 hrs/week, it ends in January)
Prof. A.D. Polosa

b) TIME-COMPRESSED (i.e. FASTER) COURSE
(8 hrs/week, it ends before November 15th) Prof. R. Bonciani

This course is mandatory for the Particle and Astroparticle Physics curriculum

The students who intend to take Electroweak Interactions must take this course.

“Free choice” courses: one at the first year, one at the second

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?

The curriculum must be balanced

FIRST year: 5 mandatory courses + English = 37 CFU
4-6 more courses = 24-36 CFU

SECOND year: 1-3 courses = 6-18 CFU
thesis + internship = 41 CFU

unbalanced curricula will not be approved

Second year

THESIS: students are advised to decide the subject and the advisor of the thesis at the beginning of the first semester

NOTE: the thesis should be consistent with the chosen curriculum and with the elective courses that one is taking

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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	Mathematical Physics	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			
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

Mandatory courses:

FIRST semester: Relativistic quantum mechanics, Condensed Matter, Physics Laboratory I

SECOND semester: Mathematical Physics, Physics Laboratory II

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

GROUP A: you have to choose 3 COURSES in this list

WARNING: each course has to be chosen in the right year and in the right semester

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	Electroweak interactions	6	1	1	FIS/02	Y
5	Nonlinear and Quantum Optics	6	1	1	FIS/03	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	Simmetrie ed interazioni fondamentali	6	1	2	FIS/02	N
12	Condensed Matter Physics II	6	1	2	FIS/03	Y
13	Superconductivity and Superfluidity	6	1	2	FIS/03	Y
14	Many-Body Physics	6	2	1	FIS/03	Y
15	Physics of Complex Systems	6	2	1	FIS/03	Y
16	Introduction to Particle Physics	6	2	1	FIS/01	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

GROUP B: you have to choose **2** courses in this list

WARNING: each course has to be chosen in the right year and in the right semester

GROUP A or B:

1) Electroweak interactions

[strongly suggested for high-energy physics]. It starts in November, when Rel. Quantum Mech (Bonciani) ends.

2) Meccanica Statistica e fenomeni critici

[strongly suggested for those interested in Statistical Mechanics and Complex systems]

3) Relatività Generale

[strongly suggested for those interested in theoretical astrophysics]

Some constraints

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

For those who choose the High Energy Physics curriculum (theory) “Introduction to particle physics” (prof. Kado) is strongly suggested (experimental course for theorists)

The course Computing methods for Physics (Prof. Rahthlou) is also suggested for the HEP curriculum

Computing methods for Physics (prof. Crisanti) is indicated for the other curricula in theoretical physics

Computing methods for Physics (prof. De Michele) is more oriented to computational physics

Computing methods for Physics is labelled as **INF** and satisfies the NON-FIS constraint


AN EXAMPLE of curriculum in PHYSICS OF FUNDAMENTAL INTERACTIONS


TABLE A	YEAR	SEM.
Electroweak interactions	1	1
Relatività generale	1	1
Nonlinear waves and solitons	1	2
Quantum electrodynamics	1	2
Quantum field theory	2	1

3 courses in this table

TABLE B	YEAR	SEM.
Electroweak interactions	1	1
Computing methods for physics	1	1
Relatività generale	1	1
Quantum electrodynamics	1	2
Simmetrie e interazioni fondamentali	1	2
Weak Interactions in the standard model and beyond	2	1
Introduction to Particle Physics	2	1

2 courses in this table

 first year
first semester


 first year
second semester


 second year
first semester


AN EXAMPLE of curriculum in STATISTICAL MECHANICS/PHYSICS OF COMPLEX SYSTEMS

TABLE A	YEAR	Sem.
Statistical mechanics and critical phenomena	1	1
Computational statistical mechanics	1	2
Meccanica statistica del non equilibrio	1	2
Quantum electrodynamics	1	2
Statistical mechanics of disordered systems	2	1
Quantum field theory	2	1

3 courses in this table

 first year
first semester


 first year
second semester


 second year
first semester


AN EXAMPLE of curriculum in STATISTICAL MECHANICS/PHYSICS OF COMPLEX SYSTEMS

TABLE B	YEAR	Sem.
Statistical mechanics and critical phenomena	1	1
Computing methods for physics	1	1
Biofisica Teorica	1	2
Computational statistical mechanics	1	2
Meccanica statistica del non equilibrio	1	2
Neural networks	1	2
Physics of complex systems	2	1
Introduzione alla teoria dei processi stocastici ed applicazioni alla fisica	2	1
Statistical Mechanics of Disordered Systems	2	1

2 courses
in this table

 first year
first semester

 first year
second semester

 second year
first semester

AN EXAMPLE of curriculum in THEORETICAL ASTROPHYSICS

TABLE A	YEAR	SEM.
Electroweak interactions	1	1
Relatività generale	1	1
Nonlinear waves and solitons	1	2
Quantum electrodynamics	1	2
Quantum field theory	2	1

3 courses
in this table

TABELLA B	YEAR	Sem
Relatività generale	1	1
Electroweak interactions	1	1
Computing methods for physics	1	1
Onde gravitazionali, stelle e buchi neri	1	2
Quantum electrodynamics	1	2
Simmetrie e interazioni fondamentali	1	2
Weak Interactions in the Standard Model and Beyond	2	1

2 courses
in this table

The 2 elective courses can be chosen in the laurea magistrale in Astronomy and Astrophysics

FOR QUESTIONS ON THE CURRICULUM
IN THEORETICAL PHYSICS:

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