Politecnico di Torino

ACADEMIC REGULATIONS

Master's degree programme

in

PHYSICS OF COMPLEX SYSTEMS

Department of Applied Science and Technology

Collegio di Ingegneria Elettronica, delle Telecomunicazioni e Fisica

Academic Year **2025/2026**

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SUMMARY

Art. 1 – Specific learning objectives and career prospects

1.1 Specific learning objectives

The Master's degree programme in Physics of Complex Systems aims to train professionals who are able to jointly apply the knowledge and methodologies of modern physics (statistical and quantum) and engineering—especially in the field of information technology—to the modelling and simulation of complex systems, i.e., systems made up of many interrelated degrees of freedom.

Graduates of this programme will be able to work with experts from specific fields and use analytical and computational tools to develop models and solve complex problems in a broad range of disciplines. These include, first and foremost, physics (e.g., understanding how the behaviour of a new material is influenced by disorder or quantum effects) and information engineering (e.g., reconstructing information corrupted by noise), as well as biophysics (biomolecular simulations and rational drug design), bioinformatics (alignment of genetic sequences, reconstruction of biomolecular interaction networks), medicine (analysis of gene expression profiles and diagnostic support) and socio-economic disciplines (traffic modelling and simulation, data analysis in the web economy).

The programme seeks to provide the following competencies:

- the ability to formulate a model of a system with many interacting degrees of freedom, using the tools of physics and information theory;
- the ability to estimate (infer) the parameters of a model by analysing large datasets;
- the ability to analyse (solve) a model using analytical and computational tools (especially simulations);
- the ability to predict the effects, behaviours and properties of a complex system based on a model;
- the ability to collaborate with specialists from a variety of fields (e.g., biologists, information theorists, engineers, economists).

A particularly important objective is to prepare graduates for pursuing a PhD in one of the disciplines covered in the programme.

1.2 Career prospects

The Master's degree programme aims to train a variety of professional profiles. The career prospects and the main functions and competencies associated to each profile are illustrated below.

Professional profile	Main functions and competencies
Specialist in modelling and simulation of stochastic processes	Functions: These specialists contribute to solving dynamic problems characterised by large random fluctuations, such as those encountered in the analysis of financial markets or turbulent fluid dynamics. They work alongside experts in the specific domain to collect large volumes of data, develop a suitable stochastic process to describe the system, and characterise its properties probabilistically, aiming—where possible—to make predictions and assess their reliability. Competencies: They are able to: • collaborate with experts in specific disciplines; • stay up to date with the state of the art in academic research in the field; • describe systems characterised by large random fluctuations through a stochastic process;

	• make probabilistic predictions and assess their reliability; • communicate results to stakeholders with different disciplinary backgrounds, including in international contexts. Potential Employers: • Financial market analysis firms • Insurance companies • Banks • Supranational financial organisations • Public and private research centres and laboratories
Specialist in modelling and description of quantum effects in matter	Functions: These professionals help to understand how quantum effects and collective phenomena determine peculiar behaviours of matter under specific conditions, with particular focus on quantum science and technology applications. They collaborate with experts in quantum property modelling to develop models that predict new phenomena and explain experimental observations, and investigate their applications, for example, in innovative nanomaterials and quantum simulators based on ultracold atoms. Competencies They are able to: • collaborate with experts in specific applications; • stay up to date with the state of the art in academic research in the field; • develop new computational models—or suitably adapt known ones—based on a deep understanding of condensed matter physics, identifying relevant degrees of freedom and appropriate spatial and temporal scales; • simulate proposed models, coordinating a team, when necessary, analyse the results, and optimise the material properties accordingly; • communicate results to stakeholders with different disciplinary backgrounds, including in international contexts. Potential Employers: • Public and private universities and research centres • Companies operating in quantum science and technology
Specialist in inference, optimisation and machine learning	Functions: These specialists contribute to finding optimal or suboptimal solutions to optimisation and statistical inference problems—often computationally intractable and characterised by a large number of interacting or competing constraints (i.e., frustrated systems). They operate in contexts requiring the processing of large volumes of data, integrating traditional optimisation and inference methods with modern machine learning techniques, including neural network-based approaches. These problems are widespread across many disciplines that involve large-scale information processing. Some examples are compressed sensing and its applications, combinatorial optimisation of constraint-based systems, biological sequence alignment, reconstruction of macromolecular interaction networks in biology, predictive modelling of fitness functions in protein families, and inference problems in dynamic or networked environments. Competencies: They can: • collaborate with domain experts; • stay up to date with the state of the art in academic research, including emerging areas such as (physics-informed) machine learning and artificial intelligence; • represent the problem in terms of interacting degrees of freedom over a graph or other appropriate mathematical structure; • identify the most suitable methods and algorithms for an (often approximate) solution; • implement these algorithms in a programming language, coordinating a team when necessary; • analyse the properties of the solutions—typically in probabilistic terms; • communicate results to stakeholders with different disciplinary backgrounds, in both academic and corporate international contexts.

	Potential Employers: • Public and private research centres and laboratories • Large consulting firms • Companies in the information processing sector (e.g., telecommunications, bioinformatics, data analysis)
Specialist in modelling and simulation of biological systems	Functions: They contribute to the analysis of biological data and the design of new drugs (rational drug design). They work with biologists and medical researchers to collect large-scale genomic, transcriptomic, and proteomic datasets, develop and analyse models to describe them—often in collaboration with bioinformaticians. They also model and simulate biological macromolecules, focusing on phenomena such as folding, binding, sorting, and molecular dynamics. This work is based on computational physics methodologies and makes use of advanced machine learning and neural network techniques. Competencies: They are able to: • collaborate with experts in molecular and cellular biology, bioinformatics, and biomedical disciplines; • stay up to date with the state of the art in academic research, including emerging areas such as (physics-informed) machine learning and artificial intelligence; • develop and simulate models of biological systems, macromolecules, and interaction networks, coordinating a team when necessary; • analyse large-scale biological data (e.g., macromolecular sequences and structures, gene expression profiles, protein–protein and protein–nucleic acid interactions); • communicate results to stakeholders with different disciplinary backgrounds, in both academic and corporate international contexts. Potential Employers: • Public and private research centres and laboratories • Pharmaceutical companies • Bioinformatics companies
Preparation for Further Studies	**Prerequisites for continuing studies**
Ph.D. programme	One of the most common prospect for graduates of this Master's degree programme is to continue their studies with a PhD in physics or in disciplines related to the topics explored at Master's level (such as biology, neuroscience, ecology, inference and optimisation, quantum and condensed matter physics, etc.). Students normally pursue a PhD degree at one of the programme's partner institutions or at other prestigious universities and research centres, such as: Scuola Normale Superiore (Pisa), École normale supérieure (Paris), École Supérieure de Physique et Chimie Industrielle (Paris), Institut Curie (Paris), École Polytechnique (Paris), Imperial College London, King's College London, University of Oxford (UK), University of Cambridge (UK), Rice University (Houston), École Polytechnique Fédérale de Lausanne, and Stanford University. The programme provides the knowledge required to be admitted and succeed in a PhD programme, including: • a solid scientific background in modern theoretical physics, especially in statistical and quantum physics; • a set of analytical and computational methods and techniques for solving—either exactly or approximately—problems involving a large number of interacting degrees of freedom; • an interdisciplinary foundation for applying modern theoretical physics to fields such as engineering, information theory, and biology.

1.3 Professional profiles (ISTAT codes)

With reference to the list of professional profiles classified by ISTAT (Italian National Institute of Statistics, https://www.istat.it/en/), graduates from this Master's degree programme can work as:

ISTAT code	Description
2.1.1.1.1	Fisici

Art. 2 – Admission requirements

Italian regulations on enrolment in Master's degree programmes require Italian universities to check that applicants meet the following requirements:

- have a **three-year Bachelor's degree or university diploma,** or **other educational qualification obtained outside Italy** and recognized as suitable for admission;
- meet **specific curricular requirements**;
- have an **academic performance considered suitable** for admission.

CURRICULAR REQUIREMENTS

As far as curricular requirements are concerned, applicants must have a Bachelor's degree or a three-year university diploma, or an educational qualification obtained outside Italy and recognized as suitable for admission. In addition, they must have gained specific knowledge and competencies during their previous academic path (credits in specific Scientific Disciplinary Fields).

In particular, applicants must have earned:

- minimum 40 credits earned in the following Scientific Disciplinary Fields (settori scientifico-disciplinari): CHIM/07, FIS/01, FIS/03, MAT/02, MAT/03, MAT/05
- minimum 60 credits earned in the following specific Scientific Disciplinary Fields (settori scientifico-disciplinari): CHIM/07, FIS/01, FIS/02, FIS/03, FIS/04, INF/01, ING-IND/31, ING-INF/01, ING-INF/02, ING-INF/05, ING-INF/07, MAT/06, MAT/07, MAT/08

The credits of the Scientific Disciplinary Fields found both in the first group and in the second group are primarily counted for the first group. The remaining credits are counted for the second group. Therefore, the credits of a course can be counted partly to reach the minimum number of credits of both groups.

Applicants who lack less than 10 credits can be admitted to the programme by the Academic Advisor of the degree programme. For applicants who lack more than 10 credits, the evaluation will be subject to the final approval of the Coordinator or the Vice coordinator of the degree programme.

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Applicants who do not meet the curricular requirements must make up for their unfulfilled curricular requirements (missing credits) before enrolment, by means of:

- **enrolment in single courses in order to make up for unfulfilled curricular requirements**: this is possible for students who need to earn up to a maximum of 60 credits. Students who enrol in single courses for this reason are allowed to include in their Personal Study Plan exclusively the courses assigned by the evaluator.
  or else,
- **credit transfer at Bachelor's level**: this is possible for students who need to earn more than 60 credits. In this case, students need to enrol in the Bachelor's degree programme that offers the credits in the specific Scientific Disciplinary Fields (core subjects and commentary subjects) required for admission to this Master's degree programme.

SUITABLE ACADEMIC PERFORMANCE

Applicants must have a suitable academic performance and an English language certificate (B2 level or above, as defined by the Common European Framework of Reference for Languages: Learning, Teaching, Assessment - CEFR).

The academic performance will be assessed as follows.

1) **Applicants from Politecnico di Torino**

Applicants can be admitted to the programme if they earned their Bachelor's degree in:

- 4 years or less - no exam average grade required (1);
- between 4 and 5 years–exam weighted average grade required: ≥21/30
- more than 5 years– exam weighted average grade required (2): ≥ 24/30

The weighted average grade is calculated on all accrued course credits (graded on a scale of 30) counting towards the achievement of the Bachelor's degree, after having subtracted the worst 28 credits. The duration of the Bachelor's path is calculated on the number of academic years in which the applicant has been enrolled at the university, starting from the first enrolment in the Italian university system:

- for full-time students: the duration of the Bachelor's path is equivalent to the number of academic years of enrolment.
- for part-time students: each year of enrolment is counted as half-year.
- for full-time students taking part in the "Dual Career" programme: each year of enrolment is counted as half-year, as for part-time students.

In the event of credit transfer, the duration of the Bachelor's path must be increased proportionally to the number of credits that have been recognized by Politecnico (10-60 CFU =1 year, etc.). The worst 28 credits must be subtracted proportionally to the number of validated credits.

(1) Applicants must have graduated by the end of the December Graduation Period
*(2) The weighted average is calculated as follows: ∑(grade*credits) / ∑credits*

2) Applicants from other Italian universities

Applicants who have a Bachelor's degree awarded by another Italian university must have a weighted average grade of all the exams ≥ 24/30, regardless of the number of years it took them to graduate. The weighted average grade (∑(grade*credits) / ∑credits) is calculated on all accrued course credits (graded on a scale of 30) counting towards the achievement of the Bachelor's degree, after having subtracted the worst 28 credits.

3) Applicants with a non-Italian educational qualification

To be admitted to Politecnico Master's degree programmes, applicants must have an academic qualification awarded by an accredited/recognized foreign university, earned after completing at least 15 years of total education (including primary school, secondary school and university).

Applicants who have attended a university programme lasting five or six academic years (different from the 3+2 system) without completing it must still meet the minimum requirement of 15 years of total education (of which at least 3 years at university level) and they must have earned at least 180 ECTS credits or equivalent. Pre-university courses or foundation years cannot be counted towards the minimum number of credits or the minimum numbers of years of total education mentioned above.

In addition to having an adequate academic background and certified knowledge of English (minimum B2 level), applicants who wish to enrol in the National Track must also have an Italian language certificate (minimum B2 level), as defined by the Common European Framework of Reference for Languages (CEFR), as an admission requirement.

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The applicant's academic performance and the consistency between the degree programmes offered by Politecnico and the applicant's previous academic background are assessed by the professors designated by Coordinator of the Collegio. The evaluation is carried out on the Apply@polito platform under the section called "Applicants with a non-Italian qualification."

A positive evaluation (offer of admission) allows applicants to enrol in the programme only in the academic year in which the application has been submitted. Admitted applicants who do not complete the enrolment process within the deadlines are required to apply again to the programme in the next academic years.

More information is available at https://www.polito.it/en/education/applying-studying-graduating/admissions-and-enrolment/master-s-degree-programmes

Art. 3 – Programme curriculum

3.1 Programme overview

The degree programme is organized into the following four disciplinary areas:

1. Statistical physics and stochastic processes: this area provides advanced knowledge of statistical physics, with a focus on phase transitions, heterogeneous and disordered systems, statistical field theory, stochastic processes and out-of-equilibrium systems.
2. Quantum physics: this area provides students with advanced quantum physics tools to study quantum systems characterised by a large number of interacting degrees of freedom, interaction effects, quantum phase transitions and out-of-equilibrium quantum dynamics.
3. Algorithms, numerical methods and simulation: this area introduces students to computational complexity and to the main numerical and simulation methods used in modern physics, as well as to the key algorithms for solving complex problems in statistical inference and combinatorial optimisation, highlighting the connections between these methodologies.
4. Biological systems: this area trains students to model and analyse complex problems in the field of biology, providing the language and knowledge needed in areas such as neuroscience, molecular and cellular biophysics, and bioinformatics, with a focus on statistical-physical and computational methods.

The programme offers two possible study tracks: an international track, which includes a mandatory mobility programme, and a national track, which is fully based in Turin. Both tracks are structured over four semesters.

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International Track

This track includes mandatory mobility across three main locations:

- Trieste, at SISSA (International School for Advanced Studies, a PhD institution with a strong international vocation) and ICTP (Abdus Salam International Centre for Theoretical Physics, a UNESCO institution);
- Turin, at Politecnico di Torino;
- Paris, at a consortium composed of Université Sorbonne, Université Paris Cité and Université Paris-Saclay.

The fourth semester is dedicated to a multidisciplinary Spring School (Spring College on the Physics of Complex Systems), which includes several modules introducing current research topics and the Master's thesis. Students can work on their thesis project at any of the partner institutions or within another research group proposed by the student.
The entire programme is English-taught. Students earn a double degree, awarded by Politecnico di Torino and by one of the Paris institutions.

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National Track

The study plan is in line with the curriculum of the international track but is carried out entirely at Politecnico di Torino. In particular, the second semester of Year 1 is shared by both tracks. All compulsory courses are English-taught, as well as some optional courses, allowing students to complete the national track entirely in English.

Students can work on their thesis project at any of the partner institutions or within another research group proposed by the student.

3.2 Organization of educational activities

The list of courses (compulsory and optional), curricula, possible organization of courses into modules, any pre-requisites and exclusions and the list of the faculty members responsible for the courses are available at: https://didattica.polito.it/pls/portal30/sviluppo.offerta_formativa_2019.vis?p_a_acc=2026&p_sdu=37&p_cds=573

The list of the Scientific Disciplinary Fields (Settori Scientifico Disciplinari) for each activity (specific subjects and complementary subjects) is available at: https://didattica.polito.it/pls/portal30/sviluppo.vis_aiq_2023.visualizza?sducds=37573&tab=0&p_a_acc=2026

Art. 4 - Student career

The Student Guide is published on the Teaching Portal every year before the beginning of the academic year. There is a specific Student Guide for each Master's degree programme. The Student Guide is available on the web site of the degree programme.

It contains information and deadlines on:

- academic calendar;
- Personal Study Plan and Annual Personal Study Plan;
- free choice credits;
- internships;
- tuition fees;
- dual career;
- classes and exams;
- class delivery;
- foreign language learning;
- studying abroad/mobility programmes;
- exam rules;
- transfers in/out and internal transfers;
- interruption, suspension, withdrawal, forfeiture;
- credit transfer.

Art. 5 - Final Examination

The final examination is worth 30 credits. Developing and writing a thesis normally requires a period of approximately 6 months of full-time work. The international track requires an 18-credit thesis and a 12-credit Spring College. The national track requires a 30- credit thesis final or, alternatively, a 12-credit internship in a company followed by an 18-credit thesis.
The Final Examination involves an analysis, a project, or an innovative application, on a topic that must be consistent with the educational objectives of the degree programme. Students are required to write a final written document (Master's thesis). The courses offered in Year 2 are organized in a way that leaves sufficient time for the development of the thesis. Students who have completed all the exams are eligible to be admitted to the final examination.
The Master's thesis serves as a comprehensive assessment of the student's mastery of technical content, organizational and communication skills, and individual work capabilities in relation to complex analyses or projects. The final examination typically requires the application of knowledge gained from multiple courses, the integration of additional elements and the ability to propose innovative ideas. The topic and the activities connected with the thesis must be agreed upon with a faculty member from the Politecnico (a thesis supervisor and an internship tutor, if this is the case). Students are allowed to work on their thesis project also at external organizations or companies, in Italy or abroad, under the supervision of a thesis supervisor from Politecnico and a tutor from the external institution.

Students are required to publicly present and discuss the preparation activities for their thesis and the corresponding results (oral defence) in front of a Graduation Examining Committee, who will evaluate both the work carried out and the presentation. The Master's thesis and its oral defence must be in English for the international track but can be either in Italian or English for the national track.
Students are required to independently conduct an innovative analysis, project or application.

Students enrolled in the international track can work on their thesis project at one of the partner institutions or other organization, prior approval of the Academic Advisor of the programme.

Students must submit their thesis application and request the thesis topic online through a dedicated procedure available in their personal page on the Teaching Portal, under the section entitled "Thesis," in compliance with the Graduation Periods deadlines published in the Student Guide – Master's Final examination Section.

The final grade is given by the Graduation Examining Committee. Its members evaluate the overall average grade of all the exams on a scale of 110. The committee may add up to a maximum of 8 points, considering the following:

- quality of the thesis work (commitment, autonomy, methodological rigor, relevance of results achieved, etc.);
- thesis oral defence (clarity in presentation, etc.);
- outstanding results achieved during the academic path (number of honours, time to graduation).

A degree with honours (lode) may be awarded at the Committee's discretion if the total score is at least 112.51.

If the thesis meets the required standards, the Committee may grant the dignità di stampa (printing honour) only if the final grade is 110 cum laude and the Committee's decision is unanimous.

More Information and Deadlines:
- Student Regulations
- Student Guide

Diploma Supplement:
In compliance with article 11, paragraph 8, of Ministerial Decrees No. 509/1999 and 270/2004. Politecnico di Torino issues the Diploma Supplement, a document that can be attached to a higher education qualification. It is designed to improve the transparency of international qualifications, as it provides the description of the curriculum successfully completed by the student. This certificate follows the European model developed by the European Commission, the Council of Europe and UNESCO – CEPES: it is issued in two languages (Italian-English) and it is composed of approximately 10 pages.

More information at: https://www.polito.it/en/education/applying-studying-graduating/academic-experience/certificates-and-other-documents

Art. 6 - References

6.1 Student Regulations

The Student Regulations define the rights and responsibilities of students and set out the administrative and disciplinary rules that all students enrolled in a degree programme or in a single learning activity at Politecnico must abide by.

6.2 Other Regulations

Particular aspects of students' academic progress are governed by specific Regulations or Calls for Applications published on its website.
In particular:

- The Tuition Fee Regulations specify the annual tuition fees that students must pay. The procedure for requesting a tuition fee reduction is explained in a dedicated guide.
- The University Regulations on Funds for Student Mobility Abroad outline the principles and rules for awarding and disbursing mobility grants. Standard procedures apply to all types of mobility programmes with unified Calls for Applications published twice a year at https://www.polito.it/en/education/applying-studying-graduating/studying-abroad
- The Code of Ethical Conduct also applies to students.