



Manifesto degli Studi del Corso di Laurea Magistrale in Matematica a.a. 2018-2019

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1. Definitions of terms used in this document

- Laurea Magistrale in Matematica = Master of Science in Mathematics.
This is what this document is about.
- Laurea = Laurea Triennale=Bachelor's Degree
This is an Italian Bachelor's Degree, lasting three years.
- Credit = Credito formativo universitario = CFU = Credit
This is the European unit for measuring the value of activities such a course, an internship, or a thesis. One credit corresponds to about 7 hours of frontal lectures, and a total of 25 hours of work for the student. 120 CFU are required for a Master.
- Settore = Settore scientifico-disciplinare = SSD
This is a nation-wide classification of University courses, sorted out in various categories. The categories (SSD) for Mathematics are the following:

SSD	Italiano	Inglese
• MAT/01	Logica Matematica	Mathematical Logic
• MAT/02	Algebra	Algebra
• MAT/03	Geometria	Geometry
• MAT/04	Matematiche complementari	Miscellanea
• MAT/05	Analisi matematica	Mathematical analysis
• MAT/06	Probabilità e statistica matematica	Probability and Mathematical statistics
• MAT/07	Fisica matematica	Mathematical Physics
• MAT/08	Analisi numerica	Numerical Analysis
• MAT/09	Ricerca operativa	Operations Research

For other settori see <http://www.miur.it/UserFiles/115.htm>

- *Curriculum* (pl. *curricula*)
Within the general framework of the Master of Science in Mathematics, it is possible to aim at gaining an in-depth knowledge and understanding of several areas of advanced Mathematics (*curriculum Advanced Mathematics*) or to aim more at acquiring knowledge useful for teaching and communicating mathematics and other sciences (*curriculum Teaching and Scientific Communication*) or to specialize in one of the *curricula* of Mathematics for Life and Data Sciences or in Cryptography. Each curriculum will have different rules in the choice of courses.
- *Piano degli studi* = study plan
Each student of the Laurea Magistrale has to specify the choices she or he is taking among the various course on offer in a document with this name. (The plural of *piano* is *piani*).
- *Orientamento* =suggested *Piano degli Studi*
Examples of possible *piano degli studi* centered on different aspects of mathematical studies.
- *Stage*: the Italian term (actually borrowed from French) for an internship.

- *Semestre* (pl. *semestri*) = semester = sem
Teaching is arranged in two periods, conventionally called semesters = six months, although they last only about 14 weeks each. The first *semestre* starts in mid-September and ends about a week before the end of December. The second *semestre* lasts from mid-February to the end of May/beginning of June.
- Corso mutuato = Mut
This is a course which is offered by a different Department or is a proxy for a course held in a different Department.
- *Corso non attivato* = N.A. = Not Available course
A course that has been active in previous years, and may well be active again in the future, but is not currently offered.

2. “Istituzione e attivazione”

The [Department of Mathematics](#) promotes the [Corso di Laurea Magistrale in Matematica](#), belonging to the class “LM-40 - Matematica”. The degree is activated starting from the Academic Year 2009/10 through the insertion in the *Database of the Offerta Formativa*.

3. Instruction language

Courses of the *Laurea Magistrale in Matematica* are taught in English.

4. Goals

The *Laurea Magistrale in Matematica* is aimed at providing an in-depth knowledge and understanding of several areas of advanced Mathematics, and of its relations to other Sciences.

5. Curriculum

The *Corso di Laurea Magistrale in Matematica* is organized into four *curricula*:

- **Advanced Mathematics**
- **Cryptography**
- **Mathematics for Life and Data Sciences**
- **Teaching and Scientific Communication**

Every student is required to formally choose one of the *curricula* and to follow the corresponding rules as stated in the [Regolamento Didattico della Laurea Magistrale in Matematica](#). Advisors of studies are available for the various *curricula*.

Any change of curriculum is subjected to a verification of the *Commissione Didattica*.

6. Admission requirements

To apply to the *Laurea Magistrale in Matematica*, a student shall fulfill both some formal requirements and a satisfactory personal qualification.

The following information is required and shall be provided according to the instructions given in the web site <http://offertaformativa.unitn.it/Im/matematica/iscrivarsi>:

- To which *curricula* the applicant is interested in;
- a detailed study plan of the Bachelor's degree, including titles and syllabi of all the courses taken;
- a document from the University that issued the Bachelor's degree with reporting, in Italian or English, the list of courses, the score obtained in each of them and the final score associated to the degree;
- work and professional experiences;
- level of knowledge of English Language, certified by internationally recognized organizations or by the University that issued the Bachelor's degree;
- a motivation statement, explaining why the student is willing to apply to the *Corso di Laurea Magistrale in Matematica*, and what he/she expects from it.

As far as the formal requirements are concerned, a Bachelor's degree lasting for three years or longer is mandatory; such a degree must provide at least the basic concepts of linear algebra and mathematical analysis. A certificate for a B1 level of English is also required.

These formal requirements are satisfied by students who possess *Laurea in Matematica* (classe “L-35 – Scienze matematiche”) or a Bachelor's Degree (*Laurea*) with at least 60 credits in the settori MAT/.

The personal qualification is evaluated by the *Commissione Didattica*, of the Mathematical Department. The *Commissione* can require a personal interview (possibly on-line) with the applicants, to better evaluate their curriculum. The interview can include questions on the main topics studied in the Bachelor's Degree; this will occur in particular if the mark obtained in the Bachelor's degree is below a

given threshold. The threshold for applicants with a *Laurea in Matematica (classe “L-35 – Scienze matematiche”)* is set to 85/110.

The student is admitted to one or more chosen curricula or to a different one as defined by the *Commissione Didattica*. Some students might be required to follow a particular *piano degli studi*.

7. Piano degli studi

Students have to submit a *piano degli studi*, which satisfies the requisites of his/her *curriculum* spelled out below. To write a proper *piano*, a total of 120 credits (120 CFU) have to be chosen in the following categories: *caratterizzanti, affini, liberi, language skill and Stage/Tesi* (see below for a short description).

a. Crediti caratterizzanti

At least 35-42 CFU depending of the curriculum in settori MAT/.

b. Crediti affini

At least 36 CFU depending of the curriculum in settori MAT/, BIO/,FIS/,SECS_P/, SECS_S/, INF/01, ING-INF/, ING-IND/, ICAR/01-02,07, M-PED/, M-PSI/1-4, M-FIL/02,05, MED/01 offered at the Lauree Magistrali of the University of Trento and at the *Laurea Magistrale in Matematica* of the *Università di Verona* (as set by Art. 5 of the *Regolamento*). Also, once the proper number of *crediti caratterizzanti* has been chosen, the student can select more *caratterizzanti* courses under the *affini* label.

c. Crediti liberi

Up to 12 CFU among any course offered at the University of Trento and at the *Laurea Magistrale in Matematica* of the *Università di Verona* (as set by Art. 5 of the *Regolamento*), subject to approval by the *Commissione Didattica di Dipartimento*.

Further *crediti caratterizzanti* and *affini* can be taken under this label.

d. Language Skills

Students are required to get a B2 certificate of English for 3 CFU.

e. Tesi /Stage (Thesis/Internship)

Several internships at companies and institutions are available. An internship has a default credit value of 12 CFU. In this case, the thesis has a credit value of 18 CFU.

Students can otherwise choose to write a thesis for 30 CFU.

The workload for the Master's Thesis (including the possible internship) is formally equivalent to one semester of full-time work (25 hours x 30 CFU).

Within each curriculum, we propose particular *piani degli studi* (called *orientamenti*) which are suggested to the students; such *orientamenti* are approved by default. Students have the opportunity to write a personal *piano degli studi* within each curriculum: such *piano degli studi* is subject to approval by the *Commissione Didattica*. Students are not allowed to repeat activities already taken in their earlier career.

REMARK

The courses marked with (*) will be offered in the academic year 2018/19 but not in the academic year 2019/20.

The corsi caratterizzanti non activated (N.A.) in the academic year 2018/19 will be activated in the academic year 2019/20.

Other courses non activated (N.A.) in the academic year 2018/19 will be activated in the academic year 2019/20 if possible and if requested by a sufficient number of students.

The *curriculum* Advanced Mathematics

Prerequisites

Students are supposed to have a basic knowledge on the following topics and a good comprehension of some of them:

Algebra (groups and rings, ideals, quotients, isomorphism theorems);
 Geometry (general and algebraic topology, topological and differentiable manifolds, basic projective geometry); Complex Analysis (in one variable);
 Measure Theory (Lebesgue measure and integration theory);
 Ordinary Differential Equations and basic examples of Equations (Laplace, heat and wave equations);
 Functional Analysis (Banach and Hilbert spaces, linear operators);
 Basics of approximation techniques in Numerical Analysis;
 Classical foundations of Mathematical Physics;
 Probability (axiomatic construction).

The graduates will meet strong demand from the business-oriented environment where problem solving and analytical skills are highly appreciated.

Students are invited to choose between the following options, which are called *orientamenti*:

- **General Advanced Mathematics**
- **Advanced Algebra and Geometry**
- **Calculus of Variations, Partial Differential Equations and Dynamical Systems**

Orientamento General Advanced Mathematics

Advisors of study: Francesco Serra Cassano, Roberto Pignatelli

A consistent study plan in this *orientamento* will comply with the following rules:

Caratterizzanti courses (39 CFU):

At least 24 CFU in the *settori* MAT/01-05
 at least 15 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Advanced Analysis	145129	9	63	MAT/05	1	Francesco Serra Cassano
Advanced Geometry	145130	9	63	MAT/03	1	Roberto Pignatelli
Computational Algebra	145135	6	42	MAT/02	1	Willem de Graaf

the remaining CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Mathematical Logic	145146	6	42	MAT/01	1	Stefano Baratella
Coding Theory and Applications	145394	6	42	MAT/02	1	Massimiliano Sala
Algebraic Geometry I	145131	6	42	MAT/03	1	Gianluca Occhetta
Partial Differential Equations	145139	6	42	MAT/05	2	Alberto Valli

At least 15 CFU in the *settori* MAT/06-09 from the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Stochastic Processes	145435	9	63	MAT/06	1	Sonia Mazzucchi
Numerical Methods for PDE	145152	6	48	MAT/08	2	Ana Maria Alonso Rodriguez
One course among the following						
Mathematical Physics - Differential Geometric Methods (*)	145908	9	63	MAT/07	2	Enrico Pagani
Mathematical Physics - Quantum relativistic Theories	145907	9	63	MAT/07	-	N. A.

Affini courses (Caratterizzanti + Affini at least 75 CFU):

Students can choose courses offered by Master's Degrees of the University of Trento or by the Master's Degree in Mathematics of the University of Verona in the *settori* MAT/* or FIS/*. In particular, the following courses can be taken as *Crediti affini*:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Set Theory (*)	145156	6	42	MAT/01	2	Stefano Baratella
Cryptography	145321	6	42	MAT/02	1	Mut from Algebraic Cryptography mod. 1 - cod. 145441
Algebraic Geometry II	145132	6	42	MAT/03	2	Luis Sola Conde
Real Algebraic Geometry (*)	145566	6	42	MAT/03	2	Riccardo Ghiloni
Geometric Analysis (*)	145538	9	63	MAT/05	1	Lorenzo Mazziere
Geometric Measure Theory (*)	145258	6	42	MAT/05	2	Francesco Serra Cassano
Advanced Statistical Methods (*)	145902	6	42	MAT/06	2	Claudio Agostinelli
Mathematical Aspects of Bioelectromagnetism and Imaging	145331	6	42	MAT/08	1	Ana Maria Alonso Rodriguez
Topics in Mathematical Physics of Quantum Theories	145567	6	42	MAT/07	2	Romeo Brunetti
Model Theory	145407	6	42	MAT/01	-	N. A.
Advanced Commutative Algebra	145558	6	42	MAT/02		N. A.
Algebraic Topology	145506	6	42	MAT/03	-	N. A.
Mathematical Control Theory	145259	6	42	MAT/05	-	N. A.

Language skills (3 CFU):

Students are required to get a B2 certificate of English.

Liberi courses (up to 12 CFU):

Students may choose courses for at most 12 CFU, among all the courses offered by the University of Trento or by the Master's Degree in Mathematics of the University of Verona. Such courses shall be consistent with the selected curriculum and shall not repeat contents already provided by other courses or in the Bachelor's degree.

Students may use 3 of these CFU to get a C1 certificate of English.

Tesi:

The course of studies is concluded with the discussion of an original thesis, under guidance of a supervisor, providing 30 CFU.

Orientamento Advanced Algebra and Geometry

Advisors of study: Claudio Fontanari, Willem De Graaf, Gianluca Occhetta

Students interested in studying topics in the algebraic - geometric area can choose the following plan of studies ("orientamento" in Advanced Algebra and Geometry).

This orientamento has a strong focus on Algebra, Geometry and their interactions, such as in algebraic geometry. In particular, a firm grasp of core algebraic and geometric notions will be required, such as groups, rings, multivariate polynomials, linear algebra, projective geometry, topological spaces, functions of one complex variable. The students of this orientamento will have the possibility to develop a research thesis on Commutative Algebra, Computational Algebra, Lie Theory, Group Theory, Algebraic Curves, Algebraic Surfaces, Higher Dimensional Algebraic Varieties, Real, Complex and Quaternionic Geometry.

The graduates will meet strong demand from the business-oriented environment where problem solving and analytical skills are highly appreciated.

The high specialization of this orientamento is well suited for pursuing PHD studies in Italy or abroad, as well as for applying to international fellowships in Pure and Applied Mathematics.

Caratterizzanti courses (42 CFU):

Course	Code	CFU	Hours	SSD	Semester	Teacher
Computational Algebra	145135	6	42	MAT/02	1	Willem De Graaf
Advanced Geometry	145130	9	63	MAT/03	1	Roberto Pignatelli
Advanced Analysis	145129	9	63	MAT/05	1	Francesco Serra Cassano
Stochastic Processes	145435	9	63	MAT/06	1	Sonia Mazzucchi
One course among the following						
Mathematical Physics - Differential Geometric Methods (*)	145908	9	63	MAT/07	2	Enrico Pagani
Mathematical Physics - Quantum relativistic Theories	145907	9	63	MAT/07	-	N. A.

Affini courses (Caratterizzanti + Affini at least 75 CFU):

At least 36 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Set Theory (*)	145156	6	42	MAT/01	2	Stefano Baratella
Advanced Group Theory	145560	6	42	MAT/02	2	Andrea Caranti
Discrete Fourier Analysis	145212	6	42	MAT/02	2	Giancarlo Rinaldo
Cryptography	145321	6	42	MAT/02	1	Mut from Algebraic Cryptography mod. 1 - cod. 145441
Algebraic Geometry I	145131	6	42	MAT/03	1	Gianluca Occhetta
Algebraic Geometry II	145132	6	42	MAT/03	2	Luis Sola Conde
Real Algebraic Geometry (*)	145566	6	42	MAT/03	1	Riccardo Ghiloni
Geometric Analysis (*)	145563	9	63	MAT/05	1	Lorenzo Mazzieri
Model Theory	145407	6	42	MAT/01	-	N. A.
Advanced Commutative Algebra	145558	6	42	MAT/02		N. A.
Algebraic Topology	145506	6	42	MAT/03	-	N. A.
Homological Algebra	145565	6	42	MAT/03	-	N. A.

Language skills (3 CFU):

Students are required to get a B2 certificate of English.

Liberi courses (up to 12 CFU):

Students, in this *orientamento*, are highly recommended to choose the free courses among the courses in settori MAT/02-03 (also from the Bachelor's degree). The following courses are particularly suggested: *Algebra Commutativa*, *Geometria Differenziale*, *Teoria algebrica dei numeri* and *Teoria di Galois*. Students may use 3 of these CFU to get a C1 certificate of English.

Tesi:

The course of studies is concluded with the discussion of an original thesis, under guidance of a supervisor, providing 30 CFU.

Orientamento Calculus of Variations, Partial Differential Equations and Dynamical Systems

Advisors of study: Raul Serapioni, Francesco Serra Cassano

This *orientamento* has a strong focus on subjects as: Calculus of Variations, Partial Differential Equations (mainly theoretical but also numerical), Ordinary Differential Equations and Dynamical Systems.

Beyond the general prerequisites of the Curriculum in Advanced Mathematics, eligible students should have a firm grasp of core topics in Analysis such as: standard notions of ordinary differential equations (linear systems and nonlinear Cauchy problem), basic notions of Partial Differential Equations (Laplace, heat and wave equations, classification), elements of Real Analysis (Lebesgue measure theory, Lebesgue integration theory, L^p spaces), first elements of Banach and Hilbert spaces, basic probability theory, basic differential geometry.

The students of this *orientamento* will have the possibility to develop a research thesis on Calculus of Variations, Analysis in metric spaces, Dynamical Systems, geometrical aspects of Partial Differential Equations, Nonlinear Partial Differential Equations, Optimal Control, Numerical Analysis of Partial Differential Equations.

The high specialization of this *orientamento* is well suited for pursuing PHD studies in Italy or abroad, as well as for applying to international fellowships in Pure and Applied Mathematics.

Caratterizzanti courses (42 CFU):

Course	Code	CFU	Hours	SSD	Semester	Teacher
Advanced Geometry	145130	9	63	MAT/03	1	Roberto Pignatelli
Advanced Analysis	145129	9	63	MAT/05	1	Francesco Serra Cassano
Partial Differential Equations	145139	6	42	MAT/05	2	Alberto Valli
Stochastic Processes	145435	9	63	MAT/06	1	Sonia Mazzucchi
Numerical Methods for PDE	145152	6	48	MAT/08	2	Ana Maria Alonso

Affini courses (Caratterizzanti + Affini at least 75 CFU):

36 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Fourier Analysis	145434	6	42	MAT/05	1	Augusto Visintin
Foundations of Analysis	145142	6	42	MAT/05	2	Fabio Bagagiolo
Geometric Analysis (*)	145538	9	63	MAT/05	1	Lorenzo Mazziere
Geometric Measure Theory (*)	145258	6	42	MAT/05	2	Francesco Serra Cassano
Stochastic Differential Equations	145159	6	42	MAT/06	2	Carlo Orrieri
Mathematical Physics - Differential Geometry Methods (*)	145908	9	63	MAT/07	2	Enrico Pagani
Mathematical Control Theory	145259	6	42	MAT/05	-	N. A.
Mathematical Physics - Quantum relativistic Theories	145907	9	63	MAT/07	-	N. A.

Language skills (3 CFU):

Students are required to get a B2 certificate of English.

Liberi courses (up to 12 CFU):

Students in this *orientamento* are highly recommended to choose the free courses among the courses in *settori* MAT/05 (both from Master's and Bachelor's degree), and especially, if not already taken during their Bachelor degree, Equazioni Differenziali Ordinarie, Calcolo delle Variazioni, Analisi Funzionale, Geometria Differenziale.

Students may use 3 of these CFU to get a C1 certificate of English.

Tesi:

The course of studies is concluded with the discussion of an original thesis, under guidance of a supervisor, providing 30 CFU.

The curriculum Cryptography

Advisor of study: Massimiliano Sala

In this highly specialized curriculum, the students will receive an introduction to modern methods in Computational Algebra, with an emphasis on its main real-life applications:

Cryptography

According to their own inclination, the students are free to choose between two options, which are called *orientamenti* in Italian:

- **Orientamento stage-oriented**
- **Orientamento research-oriented**

It remains possible for a student to choose a personal study plan, which is however subject to approval by the Department and which needs a strong motivation behind.

Prerequisites

This curriculum has a strong focus on algebra and its applications to coding theory and cryptography. In particular, a firm grasp of core algebraic notions will be required, such as the notion of groups, rings, multivariate polynomial and the arithmetic of finite fields. The ideal candidate is also expected to have some familiarity with geometry, number theory, and probability.

As regards the stage-oriented programme, also some basic programming notions will be useful, such as conditional statements, loops, and functions, as is a willingness to learn and apply more advanced concepts in unfamiliar programming languages.

As regards the research oriented programme, more advanced algebra will be useful, such as fluency in Galois theory and number theory.

Orientamento Stage-oriented

This *orientamento* is especially aimed at students who wish to work in the security department of a company. Typically, security departments of banks hire our graduates, but also IT companies and security-focused firms find their study preparation of high interest. Indeed, this *orientamento* complements a solid algebraic background with both applied courses, such as *Cryptography* or *Coding Theory and Applications*, and practical Computer Science courses, such as Java programming (*Programmazione 2*) or *Network Security*. An internship is *mandatory* to graduate. The internship can be either *external* in a company or *internal* within the Laboratory of Cryptography on a project proposed by a company.

Caratterizzanti courses (39 CFU):

Course	Code	CFU	Hours	SSD	Semester	Teacher
Algebraic Cryptography	145441	6	42	MAT/02	1	Massimiliano Sala
Cryptography Finite Fields and Symmetric Cryptography		6	42		2	
Coding Theory and Applications	145394	6	42	MAT/02	1	Massimiliano Sala
Computational Algebra	145135	6	42	MAT/02	1	Willem de Graaf
Stochastic Processes (I modulo)	145157	6	42	MAT/06	1	Mut as a part of Stochastic Processes (cod. 145435)
Scientific Computing	145427	9	72	MAT/08	2	Michael Dumbser

Affini courses (Caratterizzanti + Affini at least 75 CFU):

the following courses are mandatory

Course	Code	CFU	Hours	SSD	Semester	Teacher
Advanced Programming of Cryptographic Methods	145508	6	48	INF/01	1	Giancarlo Rinaldo
Introduction to computer and network security	145937	6	48	ING-INF/05	1	Mut DISI (0517H - cod. 145937)

and at least 24 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Computability and computational complexity	145451	6	48	MAT/01	1	Mut DISI (0517H - cod. 145451)
Advanced Coding Theory and Cryptography Modulo Advanced Coding Theory Modulo Advanced Cryptography	145395	6 6	42 42	MAT/02 MAT/03	1 2	Massimiliano Sala Edoardo Ballico
Discrete Fourier Analysis	145212	6	42	MAT/02	2	Giancarlo Rinaldo
Statistics of Stochastic Processes	145256	6	48	MAT/06	1	Claudio Agostinelli
Formal Technique for Cryptographic Protocol Analysis	145396	6	42	INF/01	2	Roberto Zunino
Data Hiding	145192	6	48	ING-INF/03	1	Mut DISI (0340H - cod. 140614)
Digital Signal Processing	145190	6	48	ING-INF/03	1	Mut DISI (0340H - cod. 145624)
Advanced Natural Language Processing and Information Retrieval	145296	6	48	ING-INF/05	2	Mut DISI (0517H - cod. 145296)
Formal methods	145056	12	96	ING-INF/05	2	Mut DISI (0517H - cod. 145056)
Network Security	145065	6	48	ING-INF/05	2	Mut DISI (0517H - cod. 145065)
Security Engineering	145298	6	48	ING-INF/05	1	Mut DISI (0517H - cod. 145622)

Language skills (3 CFU):

Students are required to get a B2 certificate of English.

Liberi courses (up to 12 CFU):

To complement the preparation in this *orientamento*, students who have not attended courses focused on Java programming in the Bachelor's degree are highly recommended to take the course *Programmazione 2*. Students may use 3 of these CFU to get a C1 certificate of English.

Tesi/stage:

The course of studies is concluded with the discussion of a Master Thesis. This point can be achieved by one of the following ways:

- an original thesis, under guidance of a supervisor, providing 30 CFU;
- an internship/placement, which assigns 12 CFU, followed by an original thesis, under guidance of a supervisor, providing 18 CFU.

Orientamento Research-oriented

This *orientamento* is aimed especially at students interested in mathematics research in Applied Algebra, with focus on Cryptography and Coding Theory, and willing to pursue a PhD in Mathematics on these subjects.

Caratterizzanti courses (39 CFU) :

Course	Code	CFU	Hours	SSD	Semester	Teacher
Algebraic Cryptography Cryptography Finite Fields and Symmetric Cryptography	145441	6 6	42 42	MAT/02	1 2	Massimiliano Sala
Coding Theory and Applications	145394	6	42	MAT/02	1	Massimiliano Sala
Computational Algebra	145135	6	42	MAT/02	1	Willem de Graaf
Statistics of Stochastic Processes	145256	6	42	MAT/06	1	Claudio Agostinelli
Stochastic Processes	145435	9	63	MAT/06	1	Sonia Mazzucchi

Affini courses (36 CFU):

all the courses from the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Advanced Coding Theory and Cryptography Modulo Advanced Coding Theory Modulo Advanced Cryptography	145395	6 6	42 42	MAT/02 MAT/03	1 2	Massimiliano Sala Edoardo Ballico
Discrete Fourier Analysis	145212	6	42	MAT/02	2	Giancarlo Rinaldo
Algebraic Geometry I	145131	6	42	MAT/03	1	Gianluca Occhetta
Formal Techniques for Cryptographic Protocol Analysis	145396	6	42	INF/01	2	Roberto Zunino

The remaining CFU can be taken from courses in *settori* MAT/ offered by the *Laurea Magistrale in Matematica* of the *Università of Trento or Verona*.

Language skills (3 CFU):

Students are required to get a B2 certificate of English.

Liberi courses (up to 12 CFU):

Students, of this *orientamento*, are **highly recommended** to choose the free courses among the courses in *settori* MAT/02-03 (also from the Bachelor's degree) and, especially, *Algebra Commutativa*, *Teoria algebrica dei numeri* and *Teoria di Galois* are particularly suggested.

Students may use 3 of these CFU to get a C1 certificate of English.

Tesi/stage:

The course of studies is concluded with the discussion of a Master Thesis. This point can be achieved by one of the following ways:

- an original thesis, under guidance of a supervisor, providing 30 CFU;
- an internship / placement, which assigns 12 CFU, followed by an original thesis, under guidance of a supervisor, providing 18 CFU.

The *curriculum* Mathematics for Life and Data Sciences

Prerequisites

Students are supposed to have a basic knowledge on the following topics and a deep comprehension of some of them:

General Topology;

Measure Theory (Lebesgue measure and integration theory);

Functional Analysis (Banach and Hilbert spaces, linear operators, ordinary differential equations, Fourier series);

Numerical Analysis;

Probability (axiomatic construction);

Mathematical Statistics.

Some basics knowledge of partial differential equations is suggested.

Students are invited to choose between the following options, which are called *orientamenti*:

- **Mathematics for Data Science**
- **Modelling, Statistics and Analysis of Biosystems**
- **Modelling and Simulation for Biomedical Applications**

It is also possible for a student to present a personal study plan that may cover applications of mathematics to different fields such as finance, economics, engineering or others. Such a study plan is subject to approval by the *Commissione Didattica* of the Department.

Orientamento Mathematics for Data Science

Advisor of study: Claudio Agostinelli

This *orientamento* is especially aimed at students who wish to work in Data Analysis departments. Banks, IT companies, medium and large size firms are very interested in students with this kind of preparation. This orientamento is also interesting for those students that would like to pursue a PhD in Statistics and/or Data Science.

Students will have the opportunity to learn the latest developments in Mathematics for Data Science, advanced tools of Probability, Mathematical Statistics, technical aspects in Machine Learning, Deep Learning and Big Data. The emphasis is in the analysis of high dimensional and complex data sets, with applications in various areas such as environmental, biology, social and economic sciences.

Caratterizzanti courses (39 CFU):

Course	Code	CFU	Hours	SSD	Semester	Teacher
Geometry and Topology for Data Analysis (*)	145905	6	42	MAT/03	1	Claudio Fontanari
Fourier Analysis	145434	6	42	MAT/05	1	Augusto Visintin
Mathematical Biology	145145	9	72	MAT/05	1	Mut QCB (0521H - Mathematical Modelling - cod. 145548)
Stochastic Processes	145435	9	63	MAT/06	1	Sonia Mazzucchi
Scientific Computing	145427	9	72	MAT/08	2	Michael Dumbser

Affini courses (Caratterizzanti + Affini at least 75 CFU):

At least 18 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Advanced Statistical Methods (*)	145902	6	42	MAT/06	2	Claudio Agostinelli
Bayesian Statistics	145561	6	42	MAT/06	2	Claudio Agostinelli, Pierluigi Novi Inverardi
Statistical Models	145914	6	42	MAT/06	1	Claudio Agostinelli
Statistics of stochastic processes	145256	6	48	MAT/06	1	Claudio Agostinelli

At least 18 CFU in the following table

Course	Code	CFU	Hours	SSD	Semester	Teacher
Tensor Decomposition for Big Data Analysis	145909	6	42	MAT/02	1	Alessandra Bernardi
Stochastic Differential Equations	145159	6	42	MAT/06	2	Carlo Orrieri
Numerical Methods for PDE	145152	6	48	MAT/08	2	Ana Maria Alonso Rodriguez
Data Analysis and Exploration	145136	6	48	INF/01	2	Mario Lauria
Deep Learning	145903	6	42	INF/01	2	Mut DISI (0517H - cod.145764)
Machine Learning	145062	6	48	INF/01	1	Mut DISI (0517H - cod. 145062)
Scientific Programming	145912	6	48	INF/01	1	Mut QCB (0521H Scientific programming - mod 2 – cod. 145540)
Big Data and Social Networks	145449	6	36	ING-INF/05	1	Mut DISI (0517H - cod. 145449)
Data Mining	145453	6	36	ING-INF/05	1	Mut DISI (0517H - cod. 145453)

Language skills (3 CFU):

Students are required to get a B2 certificate of English.

Liberi courses (12 CFU):

Students are suggested to take the free courses among *caratterizzanti* and *affini* listed above. For students missing some prerequisites in Mathematical Analysis, Probability Theory or Mathematical Statistics, it is possible to include appropriate courses (in Italian) from Bachelor's degree (*Laurea triennale*) among free-choice courses.

Students may use 3 of these CFU to get a C1 certificate of English.

Tesi/ stage:

The course of studies is concluded with the discussion of a Master Thesis. This point can be achieved by one of the following ways:

- an original thesis, under guidance of a supervisor, providing 30 CFU;
- an internship / placement, which assigns 12 CFU, followed by an original thesis, under guidance of a supervisor, providing 18 CFU.

Orientamento Modelling, Statistics and Analysis of Biosystems

Advisor of study: Andrea Pugliese

This *orientamento* provides a widespread preparation at the interface between Biological sciences, Mathematics and Informatics. Students from this *orientamento* have continued with Ph.D. studies and beyond.

An introduction to modern mathematical methods in areas of biology, ecology, epidemiology, molecular networks is provided.

Companies, in particular from the pharmaceutical sector, are interested in students with these competences in modelling and statistics.

Caratterizzanti courses (36-39 CFU):

Course	Code	CFU	Hours	SSD	Semester	Teacher
Fourier Analysis	145434	6	42	MAT/05	1	Augusto Visintin
Mathematical Biology	145145	9	63	MAT/05	1	Mut QCB (0521H - Mathematical Modelling - cod. 145548)
Statistics of Stochastic Processes	145256	6	42	MAT/06	1	Claudio Agostinelli
Stochastic Processes	145435	9	63	MAT/06	1	Sonia Mazzucchi

At least one course from the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Numerical Methods for PDE	145152	6	48	MAT/08	2	Ana Maria Alonso Rodriguez
Scientific Computing	145427	9	72	MAT/08	2	Michael Dumbser

Affini courses (Caratterizzanti + Affini 75 CFU):

All the courses from the following table

Course	Code	CFU	Hours	SSD	Semester	Teacher
Statistical Models	145914	6	48	MAT/06	1	Claudio Agostinelli
Data Analysis and Exploration	145136	6	48	INF/01	2	Mario Lauria
Network Modeling and Simulation	145910	6	48	INF/01	2	Mut QCB (0521H Biological Networks mod. 2 - cod. 145545)
Introduction to Cell Biology	145389	9	70	BIO/13	1	Mut. DISI (0517H - cod. 145389)

At least one course from the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Advanced Topics in Biomathematics	145133	6	42	MAT/05	2	Andrea Pugliese
Partial Differential Equations	145139	6	42	MAT/05	2	Alberto Valli
Advanced Statistical Methods	145902	6	48	MAT/06	2	Claudio Agostinelli
Bayesian Statistics	145561	6	42	MAT/06	2	Claudio Agostinelli, Pierluigi Novi Inverardi
Stochastic Differential Equations	145159	6	42	MAT/06	2	Carlo Orrieri
Mathematical Aspects of Bioelectromagnetism and Imaging	145331	6	42	MAT/08	1	Ana Maria Alonso Rodriguez
Deep Learning	145903	6	42	INF/01	2	Mut. DISI (0517H - cod. 145764)
Machine Learning	145062	6	48	INF/01	1	Mut. DISI (0517H - cod. 145062)
Laboratory of Biological Data Mining	145053	6	48	ING-INF/05	1	Mut. QCB (0521H - cod. 145053)

Language skills (3 CFU):

Students are required to get a B2 certificate of English.

Liberi courses:

Students are suggested to take the free courses among those listed above. For students missing some prerequisites in mathematical analysis or probability theory, it is possible to include appropriate courses (in Italian) from Bachelor's degree (Laurea triennale) among free-choice courses. Students may use 3 of these CFU to get a C1 certificate of English.

Tesi/stage:

The course of studies is concluded with the discussion of a Master Thesis. This point can be achieved by one of the following ways:

- a. an original thesis, under guidance of a supervisor, providing 30 CFU;
- b. an internship / placement, which assigns 12 CFU, followed by an original thesis, under guidance of a supervisor, providing 18 CFU.

Orientamento Modelling and Simulation for Biomedical Applications

Advisor of study: Alberto Valli

Students from this *orientamento* have the opportunity to develop strong abilities in numerical computation and to interact with clinical research in hospitals, universities and research centres. Such competences will provide students with competence to continue their studies with a PhD in Applied Mathematics or in a biomedical program, as well as to work in the biomedical sector.

A piano degli studi yielding competences in mathematics, scientific computation, physics, physiology, applicable to a range of disciplines in medicine, pharmaceutical industry, sanitary services.

Caratterizzanti courses (36 CFU):

Course	Code	CFU	Hours	SSD	Semester	Teacher
Fourier Analysis	145434	6	42	MAT/05	1	Augusto Visintin
Mathematical Biology	145145	9	63	MAT/05	1	Mut QCB (0521H - Mathematical Modelling - cod. 145548)
Mathematical Aspects of Bioelectromagnetism and Imaging	145331	6	42	MAT/08	1	Ana Maria Alonso Rodriguez
Numerical Methods for PDE	145152	6	48	MAT/08	2	Ana Maria Alonso Rodriguez
Scientific Computing	145427	9	72	MAT/08	2	Michael Dumbser

Affini courses (Caratterizzanti + Affini at least 75 CFU):

at least 39 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Partial Differential Equations	145139	6	42	MAT/05	2	Alberto Valli
Statistical Models	145333	6	48	MAT/06	1	Claudio Agostinelli
Biomedical Applications of Mathematics	145429	3	21	MAT/08	2	Eleuterio Toro
Computational hemodynamics	145428	9	72	MAT/08	2	Lucas Omar Müller
Fisiologia Molecolare	145377	6	57	BIO/09	1	Mut CIBIO (0516G - cod. 145377)
Molecular and Cellular Biophysics	145235	6	48	BIO/10	1	Mut.FIS (0518H - cod. 145235)
Bio-Medical Imaging	145338	6	48	FIS/07	2	Mut. FIS (0518H - cod. 145338)
Theoretical biomechanics	145332	9	70	ICAR/01	1-2	Davide Bigoni Luigi Fraccarollo
Physiological flow and transport in porous tissues	145392	6	42	ICAR/02	2	Alberto Bellin

Language skills (3 CFU):

Students are required to get a B2 certificate of English.

Liberi courses:

Students are invited to take the free courses among those listed above.

Students may use 3 of these CFU to get a C1 certificate of English.

Tesi/stage:

The course of studies is concluded with the discussion of a Master Thesis. This point can be achieved by one of the following ways:

- an original thesis, under guidance of a supervisor, providing 30 CFU;
- an internship/placement, which assigns 12 CFU, followed by an original thesis, under guidance of a supervisor, providing 18 CFU.

The *curriculum* Teaching and Scientific Communication

Advisor of study: Silvano Delladio

The goal of this curriculum is to cover the spectrum of knowledge and skills required to undertake mathematical teaching at secondary school's level as well as to communicate mathematics and science to a broad public.

Prerequisites

Students are supposed to have a basic knowledge on the following topics and a good comprehension of some of them:

Algebra (groups and rings, ideals, quotients, isomorphism theorems),

Geometry (general and algebraic topology, topological and differentiable manifolds, basic projective geometry),

Physics (mechanics, thermodynamics, electromagnetism),

Measure Theory (Lebesgue measure and integration theory),

Ordinary Differential Equations,

Classical Foundations of Mathematical Physics,

Probability (including the axiomatic construction) and statistics.

A consistent study plan in this curriculum will comply with the following rules:

Caratterizzanti courses (36 CFU)

At least 18 CFU in the following table

Course	Code	CFU	Hours	SSD	Semester	Teacher
Foundations of Geometry	145253	6	42	MAT/03	2	Gianluca Occhetta
Elementary Mathematics from a Higher Viewpoint	145904	6	42	MAT/04	2	Claudio Fontanari
Laboratory of Didactics of Mathematics (*)	145144	6	42	MAT/04	2	Silvano Delladio
Foundations of Analysis	145142	6	42	MAT/05	2	Fabio Bagagiolo
Experimental Mathematics Laboratory at School Level	145154	6	42	MAT/04	-	N. A.

The remaining credits shall be taken from the following list:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Mathematical Logic	145146	6	42	MAT/01	1	Stefano Baratella
Computational Algebra	145135	6	42	MAT/02	1	Willem de Graaf
Advanced Geometry	145130	9	63	MAT/03	1	Roberto Pignatelli
Algebraic Geometry I	145131	6	42	MAT/03	1	Gianluca Occhetta
Advanced Analysis	145129	9	63	MAT/05	1	Francesco Serra Cassano
Mathematical Biology	145145	9	63	MAT/05	1	Mut QCB (0521H) Mathematical Modelling - cod. 145548

The following course is mandatory

Course	Code	CFU	Hours	SSD	Semester	Teacher
Mathematical models for the Physical, Natural and Social Sciences	145151	6	42	MAT/06	1	Stefano Bonaccorsi

Affini courses (Caratterizzanti + Affini at least 72 CFU):

The following course is mandatory

Course	Code	CFU	Hours	SSD	Semester	Teacher
Modern Physics	145155	12	84	FIS/08	1	Stefano Oss

at least 18 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Teacher
Laboratory Techniques for Mathematics Teaching	145906	6	56	MAT/04	1	Elisabetta Ossanna
Statistical Models	145914	6	48	MAT/06	1	Claudio Agostinelli
Experimental Physics Laboratory at High School Level I	145153	6	56	FIS/08	1	Pasquale Onorato
Experimental Physics Laboratory at High School Level II	145215	6	56	FIS/08	2	Pasquale Onorato

Students can also choose courses in the following *settori affini*: MAT/*, FIS/*, M-FIL/02, M-FIL/05, M-PSI/01, M-PSI/02, M-PSI/03, M-PSI/04, M-PED/01, M-PED/02, M-PED/03, M-PED/04 offered by Master's Degrees of the University of Trento or by the Master's Degree in Mathematics of the University of Verona.

Language skills (3 CFU):

Students are required to get a B2 certificate of English.

Liberi courses (up to 15 CFU)

Students may choose courses for at most 15 CFU, among all the courses offered by the University of Trento or by the Laurea Magistrale in Matematica of the University of Verona. Such courses shall be consistent with the selected curriculum and shall not repeat contents already provided by other courses or in the Bachelor's degree.

Students may use 3 of these CFU to get a C1 certificate of English.

Students interesting in entering in teacher career can choose PFPTI program, please refer to the page: <http://web.unitn.it/formazione-insegnanti/47527/ammissione-al-percorso-pfpti-e-riconoscimento-cfu>

Tesi/stage:

The course of studies is concluded with the discussion of a Master Thesis. This point can be achieved by one of the following ways:

- an original thesis, under guidance of a supervisor, providing 30 CFU;
- an internship / placement, which assigns 12 CFU, followed by an original thesis, under guidance of a supervisor, providing 18 CFU.