Manifesto del
Corso di Laurea Magistrale in Matematica
COORTE 2017/18

Approvato nel Consiglio di Dipartimento del 20 aprile 2017

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.

  - *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 *Laurea Magistrale in Matematica*, 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 curricula will have different rules in the choice of courses.

- *Piano degli studi* = study plan
  Each student of the *Laurea Magistrale in Matematica* has to specify the choices 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 *piani 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://web.unitn.it/dmath/25152/requisiti-e-domanda-di-ammissione:

- 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 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 Didattica* 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*, satisfying the requisites of the chosen *curriculum* as specified below. To write a proper *piano degli studi*, a total of 120 credits (120 CFU) have to be chosen in the following categories: *caratterizzanti*, *affini*, *liberi, language skill* and *Tesi/Stage* (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 by the Lauree Magistrali of the University of Trento and at the *Laurea Magistrale in Matematica* of the *University of Verona* (as set by Art. 8 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 15 CFU among any course offered by the University of Trento and at the *Laurea Magistrale in Matematica* of the *University of Verona* (as set by Art. 8 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.

WARNING: The courses marked with (*) will be offered in the academic year 2017/18 but not in the Academic Year 2018/19. Conversely, the courses marked with (**) will be offered in the Academic Year 2018/19 but not in the academic year 2017/18.

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 Partial Differential 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 *piano degli studi* 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	Lecturer
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	Lecturer
Mathematical Logic	145146	6	42	MAT/01	1	Stefano Baratella
Algebraic Geometry I	145131	6	42	MAT/03	1	Gianluca Occhetta
Coding Theory and Applications	145394	6	42	MAT/02	1	Massimiliano Sala
Partial Differential Equations	145139	6	42	MAT/05	2	Augusto Visintin

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

Course	Code	CFU	Hours	SSD	Semester	Lecturer
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 - Quantum Relativistic Theories (*)	145907	9	63	MAT/07	2	Valter Moretti
Mathematical Physics - Differential Geometric Methods (**)	145908	9	63	MAT/07	-	N. A.

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

Students can choose courses offered by *Lauree Magistrali* of the University of Trento or by the *Laurea Magistrale in Matematica* of the University of Verona in the *settori* MAT/ or FIS/. In particular, the following courses can be taken:

Course	Code	CFU	Hours	SSD	Semester	Lecturer
Model Theory (*)	145407	6	42	MAT/01	2	Stefano Baratella
Finite Fields and Symmetric Cryptography	145141	6	42	MAT/02	2	Mut from Algebraic Cryptography mod. 2 - cod. 145441
Algebraic Geometry II	145132	6	42	MAT/03	2	Luis Sola Conde
Algebraic Topology (*)	145506	6	42	MAT/03	1	Riccardo Ghiloni
Advanced Calculus of Variations (*)	145557	6	42	MAT/05	1	Andrea Pinamonti
Mathematical Control Theory (*)	145259	6	42	MAT/05	2	Fabio Bagagiolo
Mathematical Aspects of Bioelectromagnetism and Imaging	145331	6	42	MAT/08	1	Ana Maria Alonso Rodriguez
Type Theory	145568	6	42	INF/01	2	Roberto Zunino
Set Theory (**)	145156	6	42	MAT/01	-	N. A.
Advanced Commutative Algebra (**)	145558	6	42	MAT/02	-	N. A.
Real Algebraic Geometry (**)	145566	6	42	MAT/03	-	N. A.
Geometric Measure Theory (**)	145258	6	42	MAT/05	-	N. A.
Geometric Analysis (**)	145538	9	63	MAT/05	-	N. A.
Advanced Statistical Methods (**)	145902	6	42	MAT/06	-	N. A.
Topics in Mathematical Physics of Quantum Theories (**)	145567	6	42	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 may choose courses for at most 12 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.

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

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, and on 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	Lecturer
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 - Quantum Relativistic Theories (*)	145907	9	63	MAT/07	2	Valter Moretti
Mathematical Physics - Differential Geometric Methods (**)	145908	9	63	MAT/07	-	N. A.

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

At least 33 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Lecturer
Model Theory (*)	145407	6	42	MAT/01	2	Stefano Baratella
Discrete Fourier Analysis	145212	6	42	MAT/02	2	Giancarlo Rinaldo
Advanced Group Theory (*)	145560	6	42	MAT/02		N. A.
Finite Fields and Symmetric Cryptography	145141	6	42	MAT/02	2	Mut from Algebraic Cryptography mod. 2 - 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
Homological Algebra (*)	145565	6	42	MAT/03	2	Edoardo Ballico
Algebraic Topology (*)	145506	6	42	MAT/03	1	Riccardo Ghiloni
Set Theory (**)	145156	6	42	MAT/01	-	N. A.
Advanced Commutative Algebra (**)	145558	6	42	MAT/02	-	N. A.
Real Algebraic Geometry (**)	145566	6	42	MAT/03	-	N. A.
Geometric Analysis (**)	145538	9	63	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, 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

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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	Lecturer
Advanced Analysis	145129	9	63	MAT/05	1	Francesco Serra Cassano
Advanced Geometry	145130	9	63	MAT/03	1	Roberto Pignatelli
Partial Differential Equations	145139	6	42	MAT/05	2	Augusto Visintin
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	Lecturer
Fourier Analysis	145434	6	42	MAT/05	1	Augusto Visintin
Foundations of Analysis	145142	6	42	MAT/05	2	Gabriele Anzellotti Raul Serapioni
Mathematical Control Theory (*)	145259	6	42	MAT/05	2	Fabio Bagagiolo
Advanced Calculus of Variations (*)	145557	6	42	MAT/05	1	Andrea Pinamonti
Stochastic Differential Equations	145159	6	42	MAT/06	2	Stefano Bonaccorsi
Mathematical Physics - Quantum Relativistic Theories (*)	145907	9	63	MAT/07	2	Valter Moretti
Geometric Analysis (**)	145538	9	63	MAT/05	-	N. A.
Geometric Measure Theory (**)	145258	6	42	MAT/05	-	N. A.
Mathematical Physics - Differential Geometry Methods (**)	145908	9	63	MAT/07	-	N. A.
Topics in Mathematical Physics of Quantum Theories (**)	145567	6	42	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:
– ***Orientamento stage-oriented***
– ***Orientamento research-oriented***

It remains possible for a student to choose a personal *piano degli studi*, 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	Lecturer
Computational Algebra	145135	6	42	MAT/02	1	Willem de Graaf
Coding Theory and Applications	145394	6	42	MAT/02	1	Massimiliano Sala Giancarlo Rinaldo
Algebraic Cryptography Modulo Cryptography (6 crediti) Modulo Finite Fields and Symmetric Cryptography(6 crediti)	145441	12	42 42	MAT/02	1 2	Massimiliano Sala
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 course is mandatory:

Course	Code	CFU	Hours	SSD	Semester	Lecturer
Advanced Programming of Cryptographic Methods	145508	6	48	INF/01	1	Andrea Visconti

and at least 30 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Lecturer
Advanced Coding Theory and Cryptography Modulo Advanced Coding Theory Modulo Advanced Cryptography	145395	12	84	MAT/02 MAT/03	1-2	Massimiliano Sala Edoardo Ballico
Formal Technique for Cryptographic Protocol Analysis	145396	6	42	INF/01	2	Roberto Zunino
Discrete Fourier Analysis	145212	6	42	MAT/02	2	Giancarlo Rinaldo
Statistics of Stochastic Processes	145256	6	48	MAT/06	1	Claudio Agostinelli
Network Security	145065	6	48	ING-INF/05	2	Mut DISI (0517H - cod. 145065)
Computability and computational complexity	145451	6	48	MAT/01	1	Mut DISI (0517H - cod. 145451)
Digital Signal Processing	145190	6	48	ING-INF/03	1	Mut DISI (0339H - cod. 145624)
Data Hiding	145192	6	48	ING-INF/03	1	Mut DISI (0335H - cod. 140122)
Formal methods	145056	12	96	ING-INF/05	2	Mut DISI (0517H - cod. 145056)
Advanced Natural Language Processing and Information Retrival	145296	6	48	ING-INF/05	2	Mut DISI (0517H - cod. 145296)

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:
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 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	Lecturer
Computational Algebra	145135	6	42	MAT/02	1	Willem de Graaf
Coding Theory and Applications	145394	6	42	MAT/02	1	Giancarlo Rinaldo
Algebraic Cryptography Modulo Cryptography (6 crediti) Modulo Finite Fields and Symmetric Cryptography(6 crediti)	145441	12	42 42	MAT/02	1 2	Massimiliano Sala

Course	Code	CFU	Hours	SSD	Semester	Lecturer
Stochastic Processes	145435	9	63	MAT/06	1	Sonia Mazzucchi
Statistics of Stochastic Processes	145256	6	48	MAT/06	1	Claudio Agostinelli

Affini courses (36 CFU):

all the courses from the following table:

Course	Code	CFU	Hours	SSD	Semester	Lecturer
Advanced Coding Theory and Cryptography Modulo Advanced Coding Theory Modulo Advanced Cryptography	145395	12	84	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:
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.

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 same 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 *piano degli studi* that may cover applications of mathematics to different fields such as finance, economics, engineering or others. Such a *piano degli studi* 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	Lecturer
Fourier Analysis	145434	6	42	MAT/05	1	Augusto Visintin
Mathematical Biology	145145	9	63	MAT/05	1	Mut QCB (0521H - First part of Mathematical Modelling - cod. 145548)
Scientific Computing	145427	9	72	MAT/08	2	Michael Dumbser
Stochastic Processes	145435	9	63	MAT/06	1	Sonia Mazzucchi
Geometry and Topology for Data Analysis (**)	145905	6	42	MAT/03	1	N. A.

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

At least 18 CFU in the following table

Course	Code	CFU	Hours	SSD	Semester	Lecturer
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
Advanced Statistical Methods (**)	145902	6	42	MAT/06	-	N. A.

At least 18 CFU in the following table

Course	Code	CFU	Hours	SSD	Semester	Lecturer
Big Data and Social Networks	145449	6	36	ING-INF/05	1	Mut DISI (0517H - cod. 145449)
Data Analysis and Exploration	145136	6	48	INF/01	2	Mario Lauria
Data Mining	145453	6	36	ING-INF/05	1	Mut DISI (0517H - cod. 145453)
Machine Learning	145062	6	48	INF/01	1	Mut DISI (0517H - cod. 145062)
Numerical Methods for PDE	145152	6	48	MAT/08	2	Ana Maria Alonso Rodriguez
Scientific Programming	145912	6	48	INF/01	1	Mut QCB (0521H Scientific programminig - mod 2 – cod. 145540)
Stochastic Differential Equations	145159	6	42	MAT/06	2	Stefano Bonaccorsi
Tensor Decomposition for Big Data Analysis (*)	145909	6	42	MAT/02	1	Alessandra Bernardi
Research Based Business Development (*)	145911	6	42	INF/01	2	N. A.
Deep Learning (**)	145903	6	42	INF/01	-	N. A.

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:
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, Statistics and Analysis of Biosystems
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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	Lecturer
Fourier Analysis	145434	6	42	MAT/05	1	Augusto Visintin
Mathematical Biology	145145	9	63	MAT/05	1	Mut QCB (0521H - First part of Mathematical Modelling - cod. 145548)
Statistics of Stochastic Processes	145256	6	48	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	Lecturer
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	Lecturer
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	Lecturer
Partial Differential Equations	145139	6	42	MAT/05	2	Augusto Visintin
Stochastic Differential Equations	145159	6	42	MAT/06	2	Stefano Bonaccorsi
Mathematical Aspects of Bioelectromagnetism and Imaging	145331	6	42	MAT/08	1	Ana Maria Alonso Rodriguez
Machine Learning	145062	6	48	INF/01	1	Mut. DISI (0517H - cod. 145062)
Advanced Topics in Biomathematics	145133	6	42	MAT/05	2	Mimmo Iannelli
Laboratory of Biological Data Mining	145053	6	48	ING-INF/05	1	Mut. DISI (0517H - cod. 145053)
Bayesian Statistics	145561	6	42	MAT/06	2	Claudio Agostinelli, Pierluigi Novi Inverardi
Advanced Statistical Methods (**)	145902	6	48	MAT/06		N. A.
Deep Learning (**)	145903	6	42	INF/01	-	N. A.

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

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

at least 39 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Lecturer
Statistical Models	145333	6	48	MAT/06	1	Claudio Agostinelli
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
Bio-Medical Imaging	145338	6	48	FIS/07	2	Mut. (0518H - cod. 145338)
Computational hemodynamics	145428	9	72	MAT/08	2	Eleuterio Toro
Partial Differential Equations	145139	6	42	MAT/05	2	Augusto Visintin
Molecular and Cellular Biophysics	145235	6	48	BIO/10	1	Mut. (0518H - cod. 145235)
Biomedical Applications of Mathematics	145429	3	21	MAT/08	2	Eleuterio Toro
Fisiologia Molecolare	145377	6	57	BIO/09	1	Mut. (0516G - cod. 145377)

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:
c. an original thesis, under guidance of a supervisor, providing 30 CFU;
a. 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 *piano degli studi* in this curriculum will comply with the following rules:

Caratterizzanti courses (36 CFU)

The following course is mandatory

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

At least 18 CFU in the following table

Course	Code	CFU	Hours	SSD	Semester	Lecturer
Foundations of Analysis	145142	6	42	MAT/05	2	Gabriele Anzellotti Raul Serapioni
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
Experimental Mathematics Laboratory at School Level (*)	145154	6	42	MAT/04	2	Silvano Delladio
Laboratory of Didactics of Mathematics (**)	145144	6	42	MAT/04	-	N. A.

The remaining credits shall be taken from the following list:

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

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

The following course is mandatory:

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

at least 18 CFU in the following table:

Course	Code	CFU	Hours	SSD	Semester	Lecturer
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	Mut. (0518H - cod. 145537)
Laboratory Tecniques for Mathematics Teaching (*)	145906	6	56	MAT/04	1	Elisabetta Ossanna
Topics in History of Mathematics (*)	145913	6	42	MAT/04	1	Claudio Fontanari
Statistical Models	145914	6	48	MAT/06	1	Claudio Agostinelli

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 Lauree Magistrali of the University of Trento or by the Laurea Magistrale in Matematica 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 shall choose courses for 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.

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.