Master in Mathematics (Académique)

Semestre 1

	CM (UE)	TD (UE)	ECTS
Module 1			12
Commutative Algebra	45		5
Differential Geometry	45		5
Student Project as part of a compulsary or optional course		60	2
Module 2			10
Partial Differential Equations I	45		5
Probability (Martingale Theory)	45		5
Module 3 : the students are requested to choose two of the following courses			8
Algorithmic Number Theory (optionnel)	30		4
Applied Didactics of Mathematics I (optionnel)	30		4
Basics of Discrete Mathematics (optionnel)	30		4
Probabilistic Models in Finance (optionnel)	30		4
TOTAL (cours obligatoire / cours optionnel):	**180 / 120**	**60**	**30**

Semestre 2

	CM (UE)	TD (UE)	ECTS
Module 1			12
Complex Manifolds	45		5
Homological Algebra	45		5
Mathematics Seminar		60	2
Module 2			10
Partial Differential Equations II	45		5

Master in Mathematics (Académique)

	CM (UE)	TD (UE)	ECTS
Probability (Stochastic Analysis)	45		5
Module 3 : the students are requested to choose two of the following option courses			8
Algebraic Number Theory (optionnel)	30		4
Applied Didactics of Mathematics II (optionnel)	30		4
Introduction to Continuous Time Models in Mathematical Finance (optionnel)	30		4
Introduction to Graph Theory (optionnel)	30		4
TOTAL (cours obligatoire / cours optionnel):	**180 / 120**	**60**	**30**

Semestre 3

option Financial Mathematics

	CM (UE)	TD (UE)	ECTS
Module 1			15
Advanced Stochastic Modeling and Financial Applications	30		5
Continuous-time stochastic calculus and interest rate models	30		5
SDE and PDE (Solving PDE by running a Brownian motion)	30		5
Module 2 : The students are requested to choose one lecture (30h, 5 ECTS) of the curriculum "Master in Mathematics" -Study Track "General Mathematics" ** Accessible only for students of the Study Track "Financial Mathematics"			15
Advanced econometrics (optionnel)	40	15	6
Numerical Methods in Finance (optionnel)	30		5
TOTAL (cours obligatoire / cours optionnel):	**90 / 70**	**0 / 15**	**30**

Master in Mathematics (Académique)

option General Mathematics

	CM (UE)	TD (UE)	ECTS
Module 1			15
Harmonic Analysis and Representation Theory	30		5
Supergeometry	30		5
Riemann Surfaces	30		5
Module 2 : The students may choose a lecture course (30h, 5 ECTS) of the curriculum Master in Mathematics, Study Track "Financial Mathematics" * Accessible only for student of the Study Track "General Mathematics"			15
Groebner bases and applications (optionnel)	30		5
Lie algebras and Lie groups (optionnel)	30		5
Applied Didactics of Mathematics II (+ student project) * (optionnel)	30		5
Internship in a Secondary School (1 month) * (optionnel)	60		10
TOTAL (cours obligatoire / cours optionnel):	**90 / 150**		**45**

Semestre 4

option Financial Mathematics

	CM (UE)	TD (UE)	ECTS
Module 1 : the students are requested to choose a lecture course of the curriculum Master in Mathematics -Study Track "General Mathematics" (30h, 5 ECTS) of the curriculum "Master in Mathematics" -Study Track "Genera Mathematics"			10
Fiber bundles and connections (optionnel)	30		5
Algebra and Topology (optionnel)	30		5
Stochastic Analysis, Fractional Processes and Applications to Finance	30		5
Module 2			20
Master Thesis	0		20

Master in Mathematics (Académique)

	CM (UE)	TD (UE)	ECTS
TOTAL (cours obligatoire / cours optionnel):	**30 / 60**		**30**

option General Mathematics

	CM (UE)	TD (UE)	ECTS
Module 1			10
Fiber bundles and connections	30		5
Algebra and Topology	30		5
Module 2			20
Master Thesis	0		20
TOTAL (cours obligatoire):	**60**		**40**

Algorithmic Number Theory

Module: Module 3 (Semestre 1)

ECTS: 4

Objectif: The purpose of this course is to introduce the students to various aspects of algorithmic number theory.

Description: We plan to motivate this lecture by some perspectives related to cryptology, and related areas going up to international relations. We plan more specifically to introduce algorithms used for proving that an integer is probably a prime number, explain how to compute quickly the exponentiation of an element of a group, and how to apply this, say, in the context of a public-key algorithm like RSA or the key-exchange protocol of Diffie-Hellman. We will also devote some time with finite fields, and how to describe them in an efficient way from the computational point of view. Then, we will introduce the notion of an elliptic curve defined over a field. These curves lead to commutative groups, and we will explain the law group, both from an intuitive point of view, and also with explicit formulas. Then we will focus on the situation of elliptic curves defined over finite fields, especially Z/pZ, whereas p is a prime number > 3. We will show some methods for the computation of the number of points of elliptic curves over prime finite fields, culminating with Schoof's polynomial algorithm.
A very special attention will be devoted to examples, in order to illustrate ALL the concepts.

Modalité d'enseignement: Lecture course

Langue: Anglais

Obligatoire: Non

Evaluation: Written or oral exam

Professeur: LEPREVOST Franck

Applied Didactics of Mathematics I

Module: Module 3 (Semestre 1)

ECTS: 4

Objectif: **Part 1:**
Revisiter et approfondir les concepts mathématiques clés de la fin du secondaire # Résoudre des problèmes # Préparer au concours de recrutement de l'enseignement secondaire
Part 2:
See LO-s

Description: **Part 1:**
Dénombrements et probabilities # Nombres complexes # Suites # Trigonométrie

	Part 2: Fundamental concepts of didactics of mathematics
Modalité d'enseignement:	**Lecture course**
Langue:	Français, Anglais
Obligatoire:	Non
Evaluation:	**Part 1:** Participation active aux cours Dossier d'exercices suivi d'un entretien oral **Part 2:** Personal work Continuous assessment
Professeur:	HAUSTGEN Marc Paul, HENRY Val#rie

Basics of Discrete Mathematics

Module:	Module 3 (Semestre 1)
ECTS:	4
Objectif:	**The main goal of the course is to make the students familiar with mathematical concepts and provide them with basic tools and techniques (e.g. mathematical thinking, deductive reasoning, counting and mathematical representation) which are fundamental in various fields, not only in mathematics, but also computer science, engineering, and other applied areas.**
Description:	**1- Basic mathematical logic and proofs 2- Basic set theory 3- Relations and functions 4- Basics of counting and probability theory 5- Elementary graph theory**
Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Non
Evaluation:	**Written exam and participation**
Professeur:	MARICHAL Jean-Luc

Commutative Algebra

Module:	Module 1 (Semestre 1)
ECTS:	5
Objectif:	**Learn the concepts of commutative algebra in relation to applications in algebraic number theory, algebraic geometry and other fields of mathematics.**

Master in Mathematics (Académique)

Description:	**In number theory one is naturally led to study more general numbers than just the classical integers and, thus, to introduce the concept of integral elements in number fields. The rings of integers in number fields have certain very beautiful properties (such as the unique factorisation of ideals) which characterise them as Dedekind rings. Parallely, in geometry one studies affine varieties through their coordinate rings. It turns out that the coordinate ring of a curve is a Dedekind ring if and only if the curve is non-singular (e.g. has no self intersection). With this in mind, we shall work towards the concept and the characterisation of Dedekind rings. Along the way, we shall introduce and demonstrate through examples basic concepts of algebraic geometry and algebraic number theory. Moreover, we shall be naturally led to treat many concepts from commutative algebra. Depending on the previous knowledge of the audience, the lecture will cover all or parts of the following topics: - General concepts in the theory of commutative rings + Rings, ideals and modules + Noetherian rings + Tensor products + Localisation + Completion + Dimension - Number rings + Integral extensions + Ideals and discriminants + Noether's normalisation theorem + Dedekind rings + Unique ideal factorisation - Plane Curves + Affine space + Coordinate rings and Zariski topology + Hilbert's Nullstellensatz + Resultant and intersection of curves + Morphisms of curves + Singular points**
Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Oui
Evaluation:	**Written or oral exam at the end of the course**
Professeur:	WIESE Gabor

Differential Geometry

Module:	Module 1 (Semestre 1)
ECTS:	5
Objectif:	**Differential Geometry has applications in many fields of science, e.g. in Physics, Economics, Computer Science, Engineering... The central investigated objects are differential manifolds - roughly, higher dimensional analogs of curves and surfaces. The goal of this lecture course is to extend crucial mathematical concepts, such as derivatives, integrals... to these more general spaces and to introduce further basic notions of modern geometry.**
Description:	**Content:** **1. Category of differential manifolds 2. Vector fields 3. Tensor analysis on manifolds 4. Differential calculus 5. Integration**
Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Oui

Evaluation: **Oral exam**

Professeur: PONCIN Norbert

Partial Differential Equations I

Module: Module 2 (Semestre 1)

ECTS: 5

Objectif: **The goal of the course it to get acquainted with Partial differential equations (PDE) as a powerful tool for modeling problems in science, providing functional analytic techniques in order to deal with PDE.**

Description: **Fourier transform, the classical equations, spectral theory of unbounded operators, distributions, fundamental solutions.**

Modalité d'enseignement: **Lecture course**

Langue: Anglais

Obligatoire: Oui

Evaluation: **Written exam**

Professeur: OLBRICH Martin

Probabilistic Models in Finance

Module: Module 3 (Semestre 1)

ECTS: 4

Objectif: **Introductory course to basic concepts of Mathematical Finance, also suitable for students who are not going to choose their specialization in Finance. The goal is to deepen the knowledge of modern probability theory by studying applications of general interest in an actual field of applied mathematics.**

Description: **Discrete financial markets, the notion of arbitrage, discrete martingale theory, martingale transforms, complete markets, the fundamental theorem of asset pricing, European and American options, hedging strategies, optimal stopping, Snell envelopes, the model of Cox, Ross and Rubinstein.**

Modalité d'enseignement: **Lecture course**

Langue: Anglais

Obligatoire: Non

Evaluation: **Written exam**

Professeur: THALMAIER Anton

Master in Mathematics (Académique)

Probability (Martingale Theory)

Module:	Module 2 (Semestre 1)
ECTS:	5
Objectif:	**Introduction to basic concepts of modern probability theory**
Description:	**Conditional expectations, filtrations, martingales, stopping times, optional stopping, Doob inequalities, martingale convergence and regularization theorems, Gaussian processes, canonical processes, Markov semigroups, Markov processes, Poisson processes, Brownian motion**
Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Oui
Evaluation:	**Written exam**
Professeur:	THALMAIER Anton

Student Project as part of a compulsary or optional course

Module:	Module 1 (Semestre 1)
ECTS:	2
Objectif:	
Description:	**The project is associated with one of the optional courses chosen by the student. It consists of a mathematical problem or subject that falls into line with the course content. The topic is suggested either by the lecturer or the student. In the latter case, the lecturer must approve the subject. The student is requested to submit the result of his work in the form of a mathematical text.**
Modalité d'enseignement:	Travaux dirigés
Langue:	Anglais
Obligatoire:	Oui
Evaluation:	**Supervisor**
Professeur:	PONCIN Norbert, THALMAIER Anton

Algebraic Number Theory

Module:	Module 3 (Semestre 2)
ECTS:	4
Objectif:	**Introduce the students to Algebraic Number Theory.**
Description:	**Explicit Diophantine equations Number rings Cyclotomic fields Quadratic reciprocity Geometry of numbers**
Modalité d'enseignement:	**Lecture with integrated exercises**
Langue:	Anglais
Obligatoire:	Non
Evaluation:	**Oral exam**
Professeur:	WIESE Gabor, N.N.

Applied Didactics of Mathematics II

Module:	Module 3 (Semestre 2)
ECTS:	4
Objectif:	
Description:	**Didactics of Mathematics: Improving learner achievement in calculus**
Modalité d'enseignement:	Instruction comprises lectures, workshops, project work and classroom experience. Close interaction between observation, analysis and theory of classroom practice
Langue:	Français, Anglais
Obligatoire:	Non
Evaluation:	Assessment is based upon the quality of the prepared documents and an oral examination of the reviewed and revised texts
Professeur:	TERNES Gaston

Complex Manifolds

Module:	Module 1 (Semestre 2)
ECTS:	5
Objectif:	The aim of the lecture course is to give an introduction to the theory of complex manifolds as it is needed for further studies in the field. After the course the students should understand

	the notion of a complex manifold, know the most important examples, be acquainted with the basic theorems of the theory, and master the basic techniques of the theory. The lecture course serves on one hand as a preparation for more specialized lectures in the second year of the master, and on the other hand as a preparation for writing a master thesis in the subject.
Description:	**1. Holomorphic functions in 1 variable 2. Holomorphic functions in n variables 3. Repetition: differentiable manifolds 4. Complex manifolds and their basic properties 5. Examples: projective space, Grassmannians, # 6. Sheaf of holomorphic functions 7. Meromorphic functions 8. Analytic sets and singularities 9. Tangent space and differentials, real picture 10. Tangent space and differentials, complex picture 11. Multidifferential forms, DeRham and Dolbeault operators 12. Vector bundles 13. Line bundles**
Modalité d'enseignement:	**Lecture Course**
Langue:	Anglais
Obligatoire:	Oui
Evaluation:	**Written or oral examination**
Professeur:	SCHLICHENMAIER Martin

Homological Algebra

Module:	Module 1 (Semestre 2)
ECTS:	5
Objectif:	**Homological algebra is roughly a collection of techniqu es that allow extracting information encoded in a widespread type of sequences of objects and arrows. It originates from topology, became an independent field of Mathematics in the mid 1940s, and developed in close connection with category theory. Nowadays homological algebra plays an important role in numerous areas of Mathematics, e.g. in algebraic number theory, algebraic geometry, mathematical physics# Since a modern approach to homological algebra falls outside the scope of a general first year Master course, we will try to present a more classical viewpoint.**
Description:	**- Basic concepts - Examples of cohomology theories - Computations of cohomologies - Spectral sequences - Functors Tor and Ext**
Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Oui
Evaluation:	**Oral exam**
Professeur:	PONCIN Norbert, ALTOMANI Andrea

Introduction to Continuous Time Models in Mathematical Finance

Module:	Module 3 (Semestre 2)
ECTS:	4
Objectif:	**Introduction to continuous time models in mathematical finance (Black-Scholes model)**
Description:	**Arbitrage, risk-neutral measures, option pricing, hedging, Black-Scholes-Merton equation, call-put parity, connections with partial differential equations, forwards and futures, american options, exotic options , change of numéraire, Garman-Kohlhagen formula, term-structure models, Vasicek model, Heath-Jarrow-Morton model, forward LIBOR model**
Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Non
Evaluation:	**Written exam**
Professeur:	PECCATI Giovanni

Introduction to Graph Theory

Module:	Module 3 (Semestre 2)
ECTS:	4
Objectif:	**To provide an introduction to graph theory and its applications.**
Description:	**Graphs and digraphs, Eulerian and Hamiltonian graphs, trees and spanning trees, colourings, flows in networks, matchings in biparite graphs, planar graphs.**
Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Non
Evaluation:	**Written exam and/or oral exam**
Professeur:	COUCEIRO Miguel

Mathematics Seminar

Module:	Module 1 (Semestre 2)

ECTS:	2
Objectif:	
Description:	**Each student will give at least one talk on a topic selected jointly with the supervising professor. A typewritten version of this (these) lecture(s) will be requested.**
Modalité d'enseignement:	Student Seminar
Langue:	Anglais
Obligatoire:	Oui
Evaluation:	**Participation and lecture(s) in the seminar.**
Professeur:	PONCIN Norbert, THALMAIER Anton

Partial Differential Equations II

Module:	Module 2 (Semestre 2)
ECTS:	5
Objectif:	**Learning tools in order to deal with PDE, understanding the interplay between local and global problems and techniques.**
Description:	**Distributions as generalized functions continued, Sobolev spaces, elliptic regularity, elliptic operators on compact manifolds, some non-linear equations.**
Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Oui
Evaluation:	**Written exam**
Professeur:	OLBRICH Martin

Probability (Stochastic Analysis)

Module:	Module 2 (Semestre 2)
ECTS:	5
Objectif:	**Introduction to basic concepts of Stochastic Analysis**
Description:	**Continuous martingales, stochastic integration, quadratic variation, Itô calculus, theorem of Girsanov, stochastic differential equations, Markov property of solutions, connection of stochastic differential equations and partial differential equations, martingale representation theorems, chaotic expansions, Feynman-Kac formulas**

Master in Mathematics (Académique)

Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Oui
Evaluation:	**Written exam**
Professeur:	PECCATI Giovanni

Advanced econometrics

Module:	Module 2 (Semestre 3)
ECTS:	6
Objectif:	This course is intended for research track masters students. However, Ph.D. students interested in learning this material are also welcome to enroll. Its objective is to familiarize students with microeconometric models and methods that are widely used in applied economics and social science research. We will focus on linear models in this course; nonlinear models will be covered in a subsequent course.
Description:	This course is intended for research track Masters and Ph.D. students. It is devoted to the study of nonlinear microeconometric models and methods that are widely used in applied economics and social science research.
Modalité d'enseignement:	
Langue:	Anglais
Obligatoire:	Non
Evaluation:	
Professeur:	TRIPATHI Gautam, VERMEULEN Wessel

Advanced Stochastic Modeling and Financial Applications

Module:	Module 1 (Semestre 3)
ECTS:	5
Objectif:	
Description:	**Discontinuous Stochastic Calculus; Malliavin Calculus of Variations; Transaction Costs; Fractional Processes; Incomplete Markets; Stochastic Optimization.**
Modalité d'enseignement:	**Lecture course**

Master in Mathematics (Académique)

Langue: Anglais

Obligatoire: Oui

Evaluation: Oral exam
Personal work
Continuous assessment

Professeur: PECCATI Giovanni

Applied Didactics of Mathematics II (+ student project) *

Module: Module 2 (Semestre 3)

ECTS: 5

Objectif: Part 1:
Revisiter et approfondir les concepts mathématiques clés de la fin du secondaire # Résoudre des problèmes # Préparer au concours de recrutement de l'enseignement secondaire
Part 2:
See LO-s

Description: **Part 1:**
Analyse de fonctions réelles à variable réelle # Primitives et calcul intégral # Géométrie analytique du plan et de l'espace # Coniques # Barycentres
Part 2:
Theory of Didactic Situations : Didactical, a-didactical and fundamental situations

Modalité d'enseignement: **Lecture Course**

Langue: Français, Anglais

Obligatoire: Non

Evaluation: **Part 1:**
Participation active aux cours
Dossier d'exercices suivi d'un entretien oral
Part 2:
Personal work
Continuous assessment

Professeur: HAUSTGEN Marc Paul, HENRY Val#rie

Continuous-time stochastic calculus and interest rate models

Module: Module 1 (Semestre 3)

ECTS: 5

Objectif:

Description:	**Basic Notions of Fixed Income Markets; Semimartingale Modeling; Stochastic Differential Equations; No-Arbitrage Pricing; Change of Numéraire; Short Rate Models; Heath-Jarrow-Morton Framework; Market Models; Stochastic Volatility**
Modalité d'enseignement:	**Lecture course**
Langue:	Anglais
Obligatoire:	Oui
Evaluation:	**Written exam**
Professeur:	PECCATI Giovanni

Groebner bases and applications

Module:	Module 2 (Semestre 3)
ECTS:	5
Objectif:	This module is intended as an introduction to an important computational method of algebra, that of Gröbner bases. Defining something by generators and relations is a very common situation in mathematics: in geometry, it is often useful to define a geometric object as the set of points whose coordinates satisfy some equations, in algebra, one can present an algebraic structure (e.g. a group or an algebra) by generators and defining relations... Gröbner bases give an algorithmic way to determine which relations follow from a given system - in a sense, they generalise the notion of long division to the case of defining relations.
Description:	- Gröbner bases and elimination in the commutative case: long division, Gauss-Jordan elimination, general case of solving systems of arbitrary polynomial equations. Finiteness, universal Gröbner bases. - Noncommutative associative algebras. Graded and filtered algebras. Growth. Hilbert series. Examples. Rationality of Hilbert series (Hilbert-Serre theorem, Govorov's theorem). - Gröbner bases for associative algebras. Diamond Lemma. Examples. Application: Poincare-Birkhoff-Witt theorem via Gröbner bases. Gröbner bases for left/right modules. - Basic homological algebra. (Co)bar homology, Ext and Tor groups. Anick's resolution for an augmented algebra with a Gröbner basis of relations. Koszul property vs PBW property. Examples.
Modalité d'enseignement:	Lecture course
Langue:	Anglais
Obligatoire:	Non
Evaluation:	**A written take-home exam followed by an oral exam**
Professeur:	DOTSENKO Vladimir

Master in Mathematics (Académique)

Harmonic Analysis and Representation Theory

Module: Module 1 (Semestre 3)

ECTS: 5

Objectif:

Description:

Modalité d'enseignement: Lecture course

Langue: Anglais

Obligatoire: Oui

Evaluation: Written or oral exam

Professeur: OLBRICH Martin

Internship in a Secondary School (1 month) *

Module: Module 2 (Semestre 3)

ECTS: 10

Objectif: # **To know the main regulations relating to school legislation** # **To initiate oneself to practical work in a real environment** # **To conceive teaching situations and carry them out** # **To write an internship report and defend it orally**

Description: # **Theoretical contributions on school legislation and on class management** # **Introduction to scientific writing (internship report)** # **Preparation of class activities** # **Development and marking of a class paper**

Modalité d'enseignement: **Internship preparation course - supervised work experience in a classroom**

Langue: Français, Anglais

Obligatoire: Non

Evaluation:
- **Internship report - oral presentation**
- **Evaluation by the supervisor**

Professeur: TERNES Gaston

Lie algebras and Lie groups

Module: Module 2 (Semestre 3)

ECTS:	5
Objectif:	The course is devoted to an exposition of the theory of finite-dimensional Lie groups and Lie algebras. The Lie theory originated from the works of Sophus Lie in the late of nineteenth century. Today it becomes a central topic in modern mathematics, and has applications in many areas such as geometry, analysis, representation theory and mathematical physics. The purpose of this course is to give an introduction to the subject, assuming some basic knowledge of differentiable manifolds.
Description:	1. Lie groups and Lie algebras: Frobenius theorem, Lie groups and their Lie algebras, homomorphisms of Lie groups and Lie algebras, Lie subgroups and Lie subalgebras, the exponential map, Ado theorem, Lie fundamental theorems, adjoint representations, integration on Lie groups, Weyl theorem for compact Lie groups. 2. Structure theory of Lie algebras: nilpotent Lie algebras and Engel theorem, solvable Lie algebras and Lie theorem, semisimple Lie algebras, Cartan first criterion, Cartan second criterion, Levi theorem, Schur lemma, Weyl theorem for semisimple Lie algebras, representations of sl(2,C), Clebsch-Gordan series, Cartan subalgebras and root space decomposition.
Modalité d'enseignement:	Lecture course
Langue:	Anglais
Obligatoire:	Non
Evaluation:	**Oral exam**
Professeur:	SANTI Andrea

Numerical Methods in Finance

Module:	Module 2 (Semestre 3)
ECTS:	5
Objectif:	The objective of this course is to present the numerical methods currently used in finance, especially in option pricing and portfolio optimization. The course will be organized in three parts: - PDE methods for option pricing and numerical methods in stochastic control: 15h (A. Sulem) - Monte Carlo methods: 8h (Bernard Lapeyre) - Applied sessions with computer with the computational finance software "Premia" (www.premia.fr): 7h (Jérôme Lelong)
Description:	
Modalité d'enseignement:	Course and practical exercises on the computer.
Langue:	Anglais
Obligatoire:	Non
Evaluation:	**Witten exam.**
Professeur:	SULEM Agnes, LAPEYRE Bernard, LELONG J#r#me

Riemann Surfaces

Module: Module 1 (Semestre 3)

ECTS: 5

Objectif:

Description:

1. Repetition of complex manifolds, Riemann surfaces as 1-dimensional complex manifolds.
2. Topology of Riemann surfaces.
3. Analytic structures, holomorphic and meromorphic functions.
4. Divisors, sheaves of modules associated to divisors.
5. Holomorpic and meromorphic differential forms.
6. The Riemann-Roch Theorem.
7. Integration of differential forms along curves, residue theorem.
8. Projective curves (projective varieties).
9. Complex tori and elliptic curves.
10. Jacobians of compact Riemann surfaces, Abel's theorem and Jacobi's theorem.
11. Sheaves and Cohomology.

Modalité d'enseignement: **Lecture course**

Langue: Anglais

Obligatoire: Oui

Evaluation: **Written or oral exam**

Professeur: IENA Oleksandr

SDE and PDE (Solving PDE by running a Brownian motion)

Module: Module 1 (Semestre 3)

ECTS: 5

Objectif:

Description: **Stochastic flows associated to second order differential operators, stochastic differential equations and L-diffusions, Feynman-Kac formulas and Dirichlet problems, boundary value problems (elliptic and parabolic), spectral problems of Schrödinger operators, differentiation of heat semigroups, computation of price sensitivities (Greeks)**

Modalité d'enseignement: **Written exam**

Langue: Anglais

Obligatoire: Oui

Evaluation: **Written exam**

Master in Mathematics (Académique)

Professeur: THALMAIER Anton

Supergeometry

Module: Module 1 (Semestre 3)

ECTS: 5

Objectif:

Description: **Supermathematics was inspired by supersymmetry in Particle Physics. Beyond its importance in modern Physics, Supergeometry turned out to be a powerful unifying approach inside Mathematics itself, a viewpoint that entails conceptual simplification and provides deeper understanding. The objective of the course is to accustom the students to the superversions of linear algebra and classical differential geometry, thus paving the way to quantum field theory and supergravity, as well as to Master and Ph.D. theses.**
Content: 1. Superalgebra 2. Category and sheaf theory 3. Category of smooth supermanifolds 4. Differential calculus on supermanifolds 5. Integration over supermanifolds

Modalité d'enseignement: **Lecture course**

Langue: Anglais

Obligatoire: Oui

Evaluation: **Oral exam**

Professeur: PONCIN Norbert

Algebra and Topology

Module: Module 1 (Semestre 4)

ECTS: 5

Objectif: To introduce the students to two essential notions through explicit examples (I) the notion of complexes of modules, and in particular that of Koszul complex, illustrated by the De Rham complex and the Dolbeault complex in real and complex analysis, respectively, (ii) the notion of sheaf (local/global problems) and in particular that of locally constant sheaf (and its links with multivalued functions in complex analysis) and that of locally free sheaf (vector bundles).

Description: Part I: linear algebra over a ring
(a) modules over a noncommutative ring, examples (b) operations (product, quotient, limits, Hom and tens) (c) complexes, cohomology of a complex
(d) Koszul complexes (e) applications to the Weyl algebra
Part II: applications to manifolds
(a) basic notions of sheaves (b) locally constant sheaves and locally free sheaves
(c) de Rham and Dolbeault complexes on real and complex manifolds

(d) holomorphic solutions of D-modules

Modalité d'enseignement: Lecture course

Langue: Anglais

Obligatoire: Oui

Evaluation: written exam

Professeur: SCHAPIRA Pierre

Fiber bundles and connections

Module: Module 1 (Semestre 4)

ECTS: 5

Objectif: **The objective is to give an overview of the theory of fiber bundles, vector bundles and principal bundles, and of connections on vector and principal bundles. Each lecture will contain intuitive material, definitions, propositions and theorems - the proofs of which are complete if they have an educational value - , as well as exercises and explanations concerning links with Physics.**

Description: **- Lie groups and algebras - Fiber and vector bundles - Connections on vector bundles, covariant derivative, parallel transport, curvature, torsion, Levi-Civita connection, holonomy - Principle bundles, associated and reduced bundles - Connections on principal bundles, connection 1-form, covariant derivative, curvature, holonomy, gauge theory - Characteristic classes, Chern-Weil theory**

Modalité d'enseignement: **Lecture course**

Langue: Anglais

Obligatoire: Oui

Evaluation: **Oral exam**

Professeur: PONCIN Norbert, DOTSENKO Vladimir

Master Thesis

Module: Module 2 (Semestre 4) - option Financial Mathematics

ECTS: 20

Objectif:

Description: **The master thesis in mathematics consists of the definition of a research project, the detailed explanation of research articles and/or monographs aimed at a mathematics audience, as well as of potential further developments of these. The project, which should contain parts of original mathematics, will be designed to suit the individual**

	objectives of the students, to deepen their competence in a selected field of mathematics, and to open a door towards mathematical research.
Modalité d'enseignement:	
Langue:	Anglais, Français, Allemand
Obligatoire:	Oui
Evaluation:	**Supervisor, director of studies**
Professeur:	THALMAIER Anton, PONCIN Norbert

Master Thesis

Module:	Module 2 (Semestre 4) - option General Mathematics
ECTS:	20
Objectif:	
Description:	**The master thesis in mathematics consists of the definition of a research project, the detailed explanation of research articles and/or monographs aimed at a mathematics audience, as well as of potential further developments of these. The project, which should contain parts of original mathematics, will be designed to suit the individual objectives of the students, to deepen their competence in a selected field of mathematics, and to open a door towards mathematical research.**
Modalité d'enseignement:	
Langue:	Anglais, Français, Allemand
Obligatoire:	Oui
Evaluation:	**Supervisor, director of studies**
Professeur:	PONCIN Norbert, THALMAIER Anton

Stochastic Analysis, Fractional Processes and Applications to Finance

Module:	Module 1 (Semestre 4)
ECTS:	5
Objectif:	
Description:	**i. Generalities on fractional Brownian motion ii. Integration with respect to fractional Brownian motion and application to finance iii. Malliavin calculus**
Modalité d'enseignement:	lecture course
Langue:	Anglais

Master in Mathematics (Académique)

Obligatoire: Oui

Evaluation: **Written exam**

Professeur: NOURDIN Ivan